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The Welding Engineer

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Founded by L. B. Mackenzie, 1916

APRIL, 1930 VOL. 15, NO. 4

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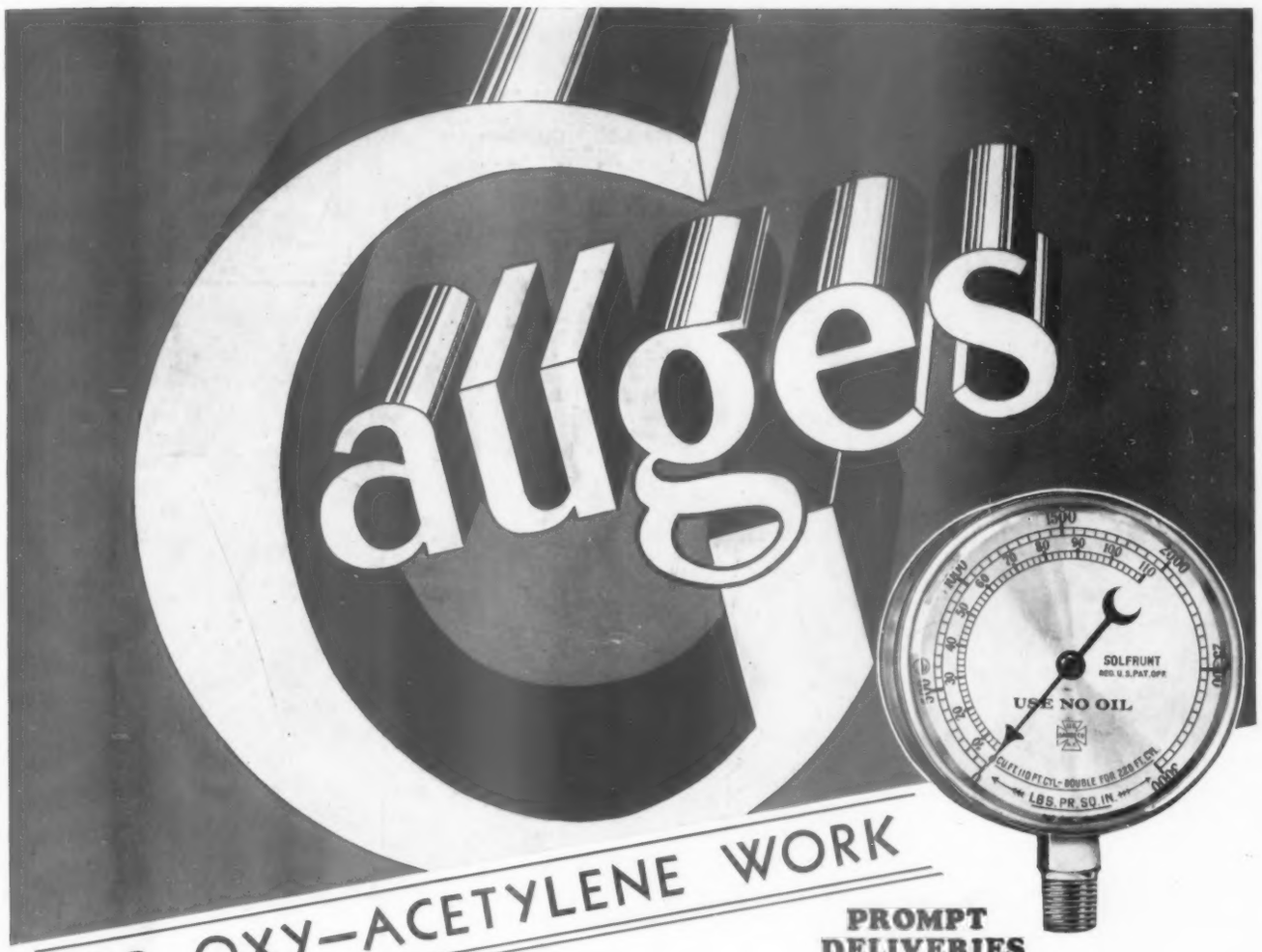

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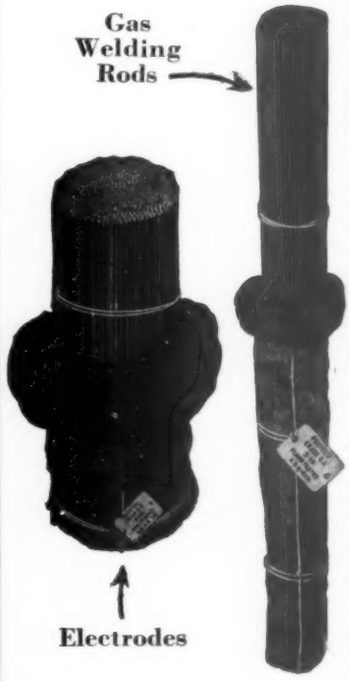

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The Welding Engineer

Founded by L. B. Mackenzie, 1916

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Improving Production Methods

REPORTS received from many manufacturers of welding apparatus and welding materials are to the effect that as a whole the business of producing these articles has not suffered during recent months. On the contrary, the volume seems to be larger than it was a year ago. This can be accounted for by the fact that executives in other industries have seen the need for improving their manufacturing methods and improving their products by using welding to a larger extent. Manufacturing costs are reduced by the adoption of simpler methods; selling costs are reduced by furnishing the sales organizations with new talking points of superiority; and even the welding operations themselves are often given the benefit of considerable savings by taking advantage of some of the latest developments in equipment and materials. This last mentioned possibility is one which should not be overlooked. A good many of the important applications of welding are still in comparatively early stages of development, and the men who use welding in these fields must watch carefully the progress which is being made in the design of equipment intended to speed up operations and decrease the opportunities for losses due to unsatisfactory work. This is a good time to be watching for the latest announcements of America's foremost manufacturers of things used in welding. In many cases these announcements will rank high as important welding news.

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The Welding Engineer does not publish in its news or advertising columns any matter that deals with or refers to either personal or legal controversies.

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Buyers' Index

Readers of The Welding Engineer will find this index to contain the most accurate information obtainable relating to welding apparatus and supplies. The advertising section includes the principal manufacturers of the United States.

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Imperial Brass Mfg. Co.
International Oxygen Co.
Kansas City Oxygen Gas Co.

EVERYBODY'S BUSINESS

BY FLOYD W. PARSONS

WE are worried about unemployment and overproduction What the cause and what the remedy?

Machinery has supplanted muscularity. We have substituted labor-saving devices for manpower more rapidly than we have created new industries, and the periodic result is an unbalanced situation that requires adjustment.

Robots and Jobless Men

Hasty condemnation of a life founded on machinery is ill-considered. It is our clever mechanical contraptions that have brought us such a tremendous increase in national efficiency. They have made it possible to produce more goods with greater skill, with less actual sweat and with shorter hours.

In the last 15 years the industrial output of the United States has increased 75 per cent while the number of workers has increased only 20 per cent. Each citizen now possesses the equivalent of 175 slave-power in the form of mechanical energy. As a result real wages have gone up, leaving more money available for added comforts and increased savings.

The "Good Old Days" Were Not So Good

Who would want to go back to the time when tons of coal were handled in boiler rooms by human hands instead of automatic stokers? Where would there by any advantage in discarding the self-operating telephone system in which a simple dial takes the place of a "hello" girl? Must we give up the machinery now employed in glass manufacture merely because it wiped out the picturesque glass blower? Shall we discard the powerful magnets employed by our steel companies in order to bring back jobs for workmen who handle steel billets?

Better machines have made it possible to turn out 32,000 razor blades in the same time that was required to produce 500. Only a few years have passed since the hourly output of four-ounce bottles was 77—now it is 3,000. Because of speedy labor-saving devices the average wholesale value of American automobiles is $542 apiece, and they are being turned out at the rate of nearly 5,000,000 a year. But if automobiles were hand-made it is estimated the cheapest modern type would cost $10,000, and as a result, there would be work for only a very small percentage of the 4,800,000 people who are occupied in either building automobiles or in taking care of an endless variety of jobs in industry created by the motor car.

Today's Air-Operated Messengers

Networks of pneumatic tubes serving executive offices in big buildings do the work of thousands of messenger boys. Mail and telegrams fly regularly to their destinations via underground "airways." All of the New York City post offices are connected by tubes that handle 10,000,000 letters a day.

One steel company uses asbestos-lined pneumatic tubes to carry 300 specimens of hot steel daily to the testing laboratory from the blast furnaces. A 10-in. pneumatic pipe, lowered into a barge by a derrick will suck up 100 tons of grain every hour and deposit it in a nearby grain elevator.

Queer things are carried by our industrial pneumatic tubes. Nails, buckshot, poisonous black arsenic, coal, brazil nuts and the cocoanut hulls used in the making of cocoanut oil are all transported from place to place by this ingenious method. Wood pulp is propelled by air through tubes seven miles long in Louisiana, and 16-ft. planks are "floated" on air in a 40-in. pipe in Oregon.

Equally amazing is the progress in cable making. Blocks of granite rise out of quarries on slings hung from wire rope. Aerial railways carry huge logs from the North woods to distant mills, and transport apples from irrigated orchards to the nearest railroad stations. Small cables will swing big locomotives gently into the hold of a steamer, and a few big ones, each 3 ft. thick, will sustain a dead weight of 350,000 tons, approximately the weight of six ships of the Leviathan's size. Truly, wire rope has become a mighty factor in American life.

Nowhere has science done a better job than in the field of communication. A new telephone cable will carry 1,800 telephone conversations at once, and this will reduce the necessity of so frequently tearing up city pavements to replace overcrowded pipes and wires. Coded telegraph messages can now be flashed through cables across the Atlantic at a speed of 2,500 letters per minute—faster than the human voice could transmit them.

Developments in Transportation

A combination of wings and wheels now takes passengers across the country in 48 hours. Many trains are maintaining a maximum speed of 70 miles an hour on long hauls. Rails are heavier, track inspection closer, roadbeds better, locomotives more powerful, and improved signal systems will stop a train automatically.

Several large railroads are experimenting with oil-electric locomotives. This type of engine generates its own power, is clean and smokeless, can be geared to do 100 miles an hour, starts quickly, and costs only 30 cents a train-mile as compared with an average operating cost of from 75 cents to $1.10 for steam locomotives.

The "electric eye" will count the number of automobiles going through a tunnel or the people who enter a gate or door. It will detect the first wisp of smoke from burning material and instantly release carbon dioxide from a cylinder to extinguish the fire. One of these photo-cell mechanisms used in the tobacco industry automatically "looks" at each cigar fed through it; determines its shade and causes it to be placed in its proper compartment in the machine. This method is based on the fact that a cigar of light color reflects more rays than a darker one.

"Thinking" Mechanisms That Supplant Men's Skill

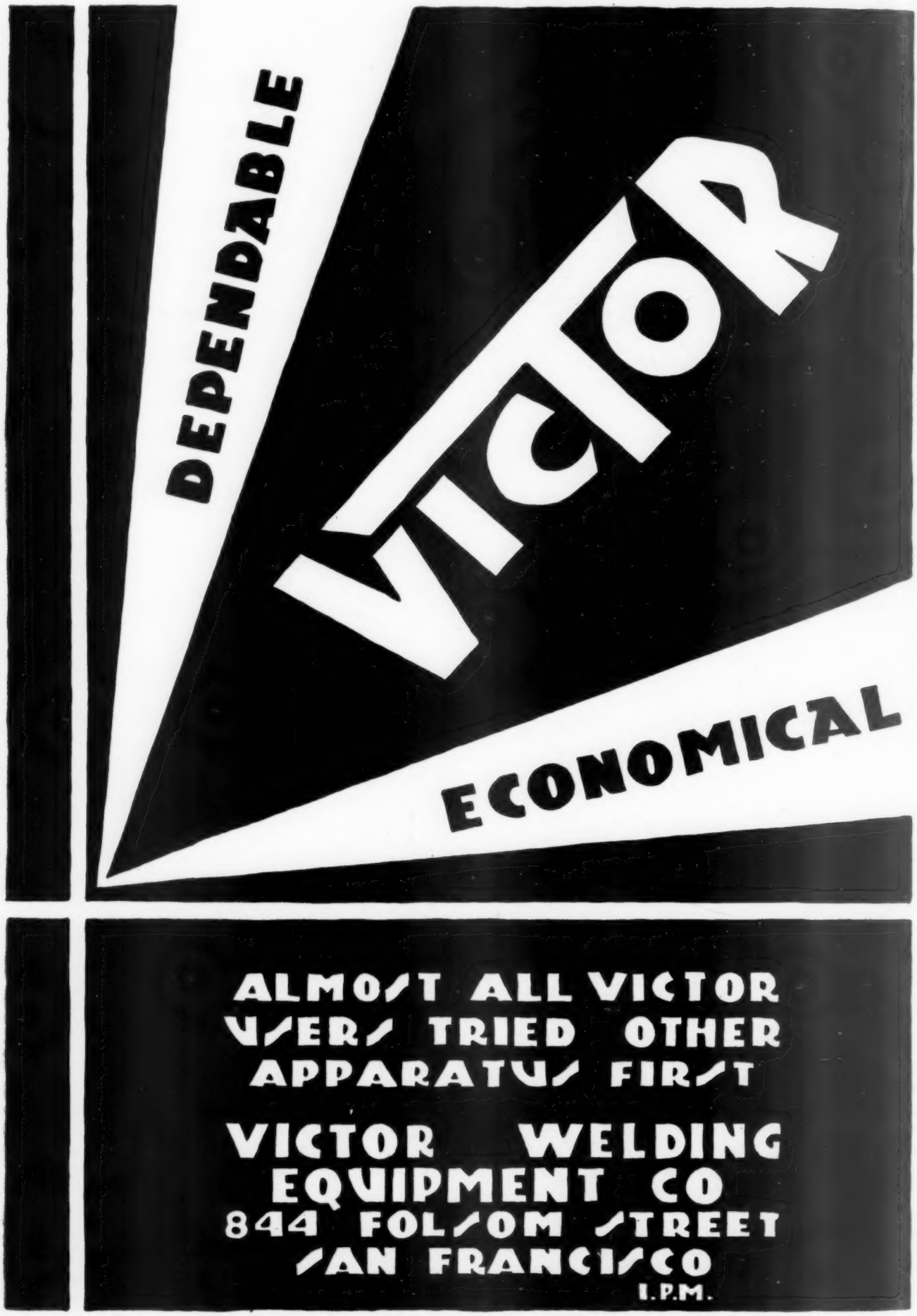
Machines are available to make porosity tests of all sorts of fabrics; to detect the beating pulse in a finger tip and write a record of it on a chart; to probe into the emotional reactions of the human mind and reveal hidden emotions; to measure the mental and physical alertness of an applicant for a job; to foretell earthquakes; to slice meat, time eggs, cut butter, wash dishes and toast bread.

New mechanical aids are making it possible for us to get along with fewer traffic policemen, fewer soldiers, fewer miners, fewer musicians, fewer sales people and a smaller force of office workers. New electric apparatus makes it possible for fewer men to kill more whales, and monster electric shovels that take 16 cu. yd. of earth at a bite do the work of hundreds of laborers.

Man has become permanently a "tool-using animal." It is as useless to advise the average person today to return to hand labor as it is to suggest that he grow fur, or sprout wings. Let us lay low the ghost of the machine myth. Labor-saving devices increase the demand for workers under conditions that ever grow better.

We should not fail to recognize the enduring nature of the multitude of mechanical betterments that have raised American life and industry to the highest levels ever attained. In a period of wide mechanization, we must expect to see distressing superficial and incidental effects such as unemployment and overproduction. But soon we will commence to hear of the creation of new industries and the expansion of old ones, commodity prices will return to levels that are fair and profitable, idle hands will find employment and faith in the future will be restored.

Civilized man's desire for manufactured comforts and luxuries is unsatiable, and he will continue to work indefinitely to secure them. If there is a limit, it is not yet in sight.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EDITORIAL

Keep the Welder at Work

A SPEAKER at one of the recent welding meetings made quite a point of the importance of continuous employment for keeping the welder contented with his job. There is, of course, some dissatisfaction to be expected if any good craftsman is obliged to wait for a long period between jobs while something else is being found for him to do; but there is no question that it is also an unwelcome duty for a good operator to be obliged to leave his equipment idle while he takes care of the preliminary work incidental to getting a job ready. The ideal plan is one which permits the operator to stay with his torch or arc continuously. The practical way to do this is to arrange for each operator to notify the management when he is nearly through with one operation so that helpers can be put to work assembling the materials and jigs necessary for the next job. Planning operations in this way is evidence of a real interest in the operator's welfare, regardless of whether he is paid on a piece work rate or by the hour. In either case, the total job cost is practically certain to be reduced.

Procedure Control Welding

OWING to the tendency to put the welding of important structures on a procedure control basis, there are many inquiries as to just what procedure control welding is, and other inquiries as to how one can learn this method of welding. This indicates an impression that the welder and his employer are up against something new and mysterious. In all cases where welding operations have been habitually performed in a haphazard sort of way, without systematic checking of all the factors involved, even though a conscientious effort is made to get a good result, the welding organization certainly is up against something new. Fortunately, however,, there is nothing intricate or mysterious about it. Procedure control welding is systematic welding. It takes into account all of the things which must be done correctly to get a good result, and establishes a program of operations for each kind of welding job which is intended to prevent the omission of any of the precautions which are considered necessary for first-class work. Procedure control welding means that the materials to be welded are inspected to be sure that a satisfactory weld can be made; that the equipment to be used is inspected to make sure that it has the right capacity for the job in hand; that the filler rod is inspected to make sure that it is suitable; that the design of the job is checked to make sure that the right kind of a weld is being used, and that it is being located so that it will work to the best advantage and as nearly as possible so that it will be a convenient weld to make; that the operator is checked to make sure that he has sufficient skill, and in case of doubt, certain tests are required to allow him to prove his ability with the torch or with the arc; that the actual welding procedure is carefully specified, such details as tip sizes, gas pressures, size of rod, amount of current, correct voltage, and even rate of welding and the order and direction in which welds should be made, being included in these specifications; and finally, wherever it is considered necessary instructions are given for testing the completed job. In all cases, directions are given for supervising and inspecting the work as it progresses. All this is neither mysterious nor complicated. It is simple and complete. It is a method of organizing welding operations in a systematic way in order that no single factor which might lead to failure escapes attention. In other words, procedure control specifications are methods of correct procedure. Such specifications need not be burdensome. They are more likely to be helpful. In fact, experience has shown over and over again that this systematic control reduces costs while it is protecting the welding organization against failures, and even because it protects against failures. It is only when one becomes seriously interested in learning how to do the best kind of work that he realizes what a big item the cost of failure may be if haphazard methods are used in welding. The welding organization which establishes procedure control methods is simply applying the same common sense principles of operation to welding which are used in connection with other manufacturing processes. The welder employed by such an organization is fortunate, because he is working with all conditions in his favor and is not assigned to work for which he has not developed sufficient skill, or expected to be responsible for things which it is the duty of a qualified inspector to watch.

What's the Cost of a Safety Department?

THE establishment of safety departments in many industrial plants is a result of a conviction that organized efforts along the line of accident prevention is an investment that pays dividends the amount of which can be as accurately determined as the savings that accrue from an investment in an economical machine. The reduction made in industrial accident claims is a saving that should be credited to the safety department; and if the department operates on less than this figure, the difference is the profit made by the department. As an example, a case has been cited in which a plant employing 4,000 men spent $175,000 for industrial accidents, or about $44 per man, in the year 1918. In 1928 this same plant spent only $30,000 for industrial accident claims plus the cost of the safety department, or about $7.50 per man on the payroll. Whether all this saving in claims was the result of the establishment of a safety department probably could be determined by an inspection of the records of the plant. If such was the case, the safety department is saving the company $36.50 per employe per year. Another company reduced its industrial accident costs from around $30 per man in 1926 to less than $7 per man in 1928. And in all such cases as these there is yet an additional saving that cannot be arithmetically determined, because certain factors enter the problem that are difficult if not quite impossible of quantitative determination; for example, an increased satisfaction of the worker and ease of his mind and a greater respect for the organization that employs him, all of which result in a higher morale, reduced labor turnover, and a greater production and better quality of goods. Hence, income from sales is increased and at the same time costs are lowered. But the worker also profits in the way of more regular employment at good wages. So, waht really is the cost of a safety department? The answer depends on the point of view. The bookkeeper will total the costs of department salaries, stationary, publicity, etc., and call that the cost of the department. The office manager will deduct that bookkeeper's figures from the amount the department has saved the company in accident claims, and this balance, he says, is what the department saves; that is, it costs nothing and saves so much per year. The man, however, whose eyes are not only on the costs sheets but on the weighty problems (and their consequences) of employe welfare, will have still another, and more favorable, conception of safety-department costs; for he tries to sense the relationship that human well-being bears to production—a factor that cannot be ignored.

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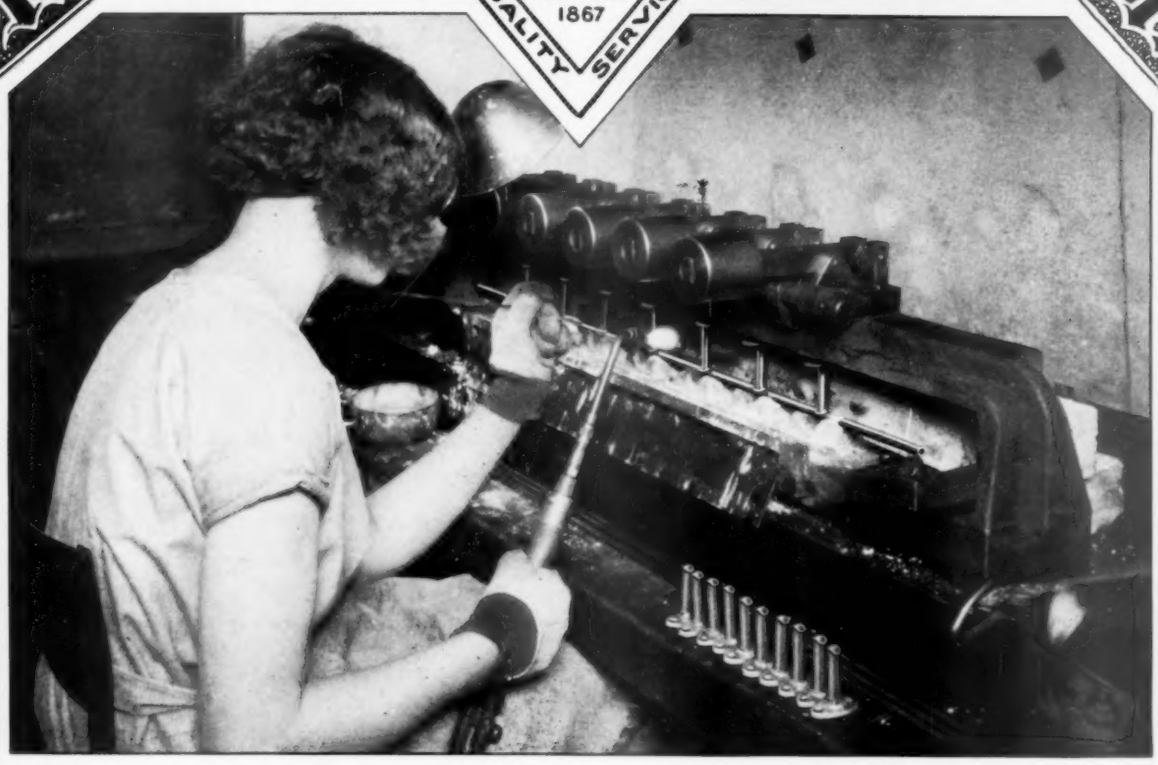

a good way to get

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(Including Airplane)

Welders, who can show that they are expert in

"Silver-Brazing"

have a strong "talking-point" in their solicitation of contracts from automobile, motor truck, and bus builders. Airplanes, too.

***Handy* Silver Solders**

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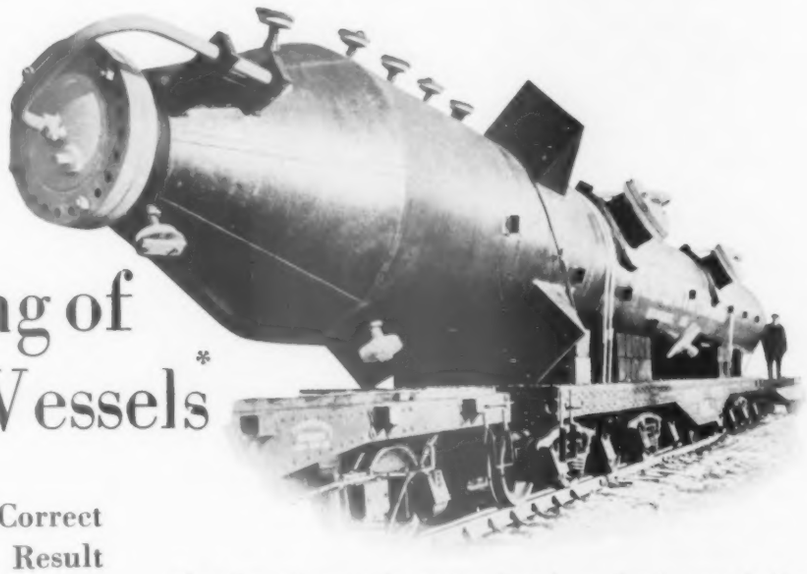


70-Ft. Welded Oil-Cracking Still With 3½-In. Shell, for Operation at 1,000 Deg. F. and 400 Lb. Pressure.

Electric Welding of High-Pressure Vessels*

Proper Welding Procedure and Correct Design of Heads and Manholes Result in Equal Strength of All Parts

By T. McLean Jasper†

THIS paper does not take up the brief for arc welding in general, because the common application of this process does not recognize some of the fundamental laws of physics which are essential to the production of good welding of any kind. It is not my purpose in this talk, however, to outline these fundamentals in detail, because it would take too much time and space. I will only indicate to you in a general way the possibilities of arc welding, some of the most necessary fundamentals for accomplishing the weld results shown, and some of the possible means for finding out whether or not you have a good weld after it is made.

The possibilities of arc welding are so great that its application in the joining of steel is almost unlimited. Arc welding of solid sections 18 in. in diameter has been made in which the welds are stronger than the steel joined. Welding of steels varying greatly in chemical composition is possible, and welds of a strength up to 200,000 lb. per sq. in. have been produced.

Of greatest significance is the fact that high fatigue, impact, and ductility values can be obtained when proper welding is done. However, it is unfortunately true that there is a vast amount of welding in service which is not representative of those qualities. Nevertheless, we are to-day on the threshold of developments in arc welding which promise still further to expand the possibilities of materials construction.

Welded Joints Allow Uniform Stress Distribution

A point which is not generally understood or taken advantage of is the considerable saving of material that is possible with a joint as strong as the plate itself, accomplished without increasing the joint section over that of the plate. It is also possible to eliminate lap joints with their undesirable eccentric loading. This elimination of lap joints and butt straps enables us to make further savings in weight and at the same time reduce the stress intensification brought about by stiffening of a vessel section.

Proper use of electric welding has lately made possible the full utilization of high-strength alloys and again savings in weight have been effected.

It is, of course, necessary that the designs embodying welded joints should be suited to the application of welding, if full advantage of this method is to be gained. The entire structure must be designed with the aim to produce uniform stress condition under load. Often fatigue is blamed for failure when the real reason is structural weakness due to poor design.

It has been found, for example, that dished heads and unreinforced openings very seriously decrease the strength of boilers and similar pressure vessels. It seems curious that this was not appreciated long ago; but by studying the general methods of construction, one can readily see the reason for this. When the stress in a riveted boiler reaches about 50 per cent of the strength of the steel, the joints yield and become so distorted that leakage occurs before the weaknesses in design show up.

Actual Factor of Safety in Conventional Riveted Design

Many riveted vessels which are considered to have a factor of safety of 5, really have a safety factor of only about 3, because the unreinforced openings, dished heads, and saddle manholes have a demonstrated strength of but 60 to 80 per cent of the cylinder strength.

In this connection, it is interesting to note that over 1,000 welded vessels have been built for the oil industry in which the factor of safety is a minimum of 3, based on the actual working conditions. Some of these vessels have been in continuous service for more than four and one-half years. All the vessels are subjected to continuous temperatures of 900 deg. F. or over, and pressures equivalent in stress to about one-third the strength of the steel used.

It is not my intention here to discuss factors of safety, but just to point out that the steam industry, as represented by the Boiler Code Committee, claims to be working with a larger factor of safety than they really have. As a matter of fact, they are carrying about 40 per cent of the metal in their boilers for which no economic value is obtained.

Figs. 1 and 2 are self-explanatory, and will impress upon you the importance and value of correct designs. They show by comparison why structural efficiencies should be very carefully analyzed in order that the highest possible joint efficiency may be utilized.

Correct Procedure Insures Good Welds

Some of the most fundamental requirements to be applied in order to insure good welds may be stated briefly as follows:

It is generally essential that the welds should be made of the same composition of steel as the plates joined, in order to avoid corrosion and electrolysis.

The welds must be free from inclusions and gases, which have an embrittling effect as well as in many cases excite corrosion. The method of applying the welding process must not create a zone of weakness immediately adjacent to it—one which is of lower strength than the original plate.

The resulting weld must be as strong as the plate,

*Abstracted from paper presented before the Western Society of Engineers, Chicago, March 24, 1930.

†Director of Research, A. O. Smith Corporation, Milwaukee, Wis.

have energy-absorbing ability equal to that of the plate, and have ductility appropriate to the work in hand.

That the above requirements are not unattainable has been amply demonstrated. At least when welding is applied to a hazardous process the above qualities should be demanded as a matter of course. These qualities can be obtained in welding by:

Using the proper weld rod.

Using the proper energy balance through the rod.

Using a deoxidizing and denitrifying atmosphere around the hot metal, thus protecting it from the surrounding air.

Relieving the stresses, developed during the process of manufacture, after the work is completed.

On the subject of good welds, it might be said that many of the ills associated with welding can be traced to the human element. The tediousness of hand welding cannot help but show a serious variable in the quality of the weld. However, there is no reason why the important welds on important structures may not be automatically made. At least, this is true when the electric arc is used.

Automatic Control Is Factor in Good Welding

Automatic control of welding eliminates the manual fatigue which necessarily attends hand-welding operations. It allows the production of a consistently good weld through the period of operation. Electric control of such operations can be made so precise that once the correct combination of weld rod, voltage, and amperage is found, only very slight adjustments on the control mechanism are called for at times.

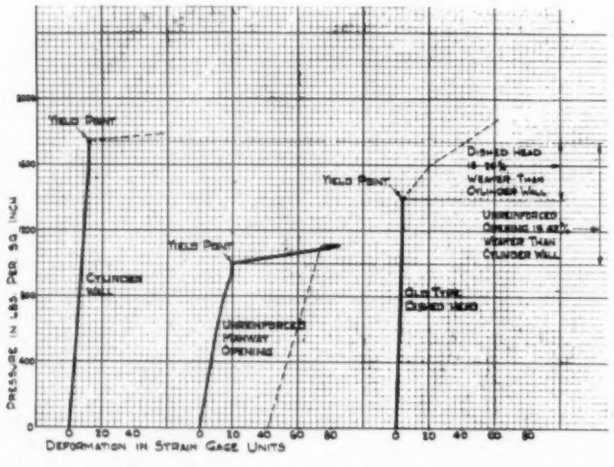


Fig. 1. Illustrating Lack of Uniformity in the Strength of a Pressure Vessel Equipped With Conventional Dished Heads and Unreinforced Openings.

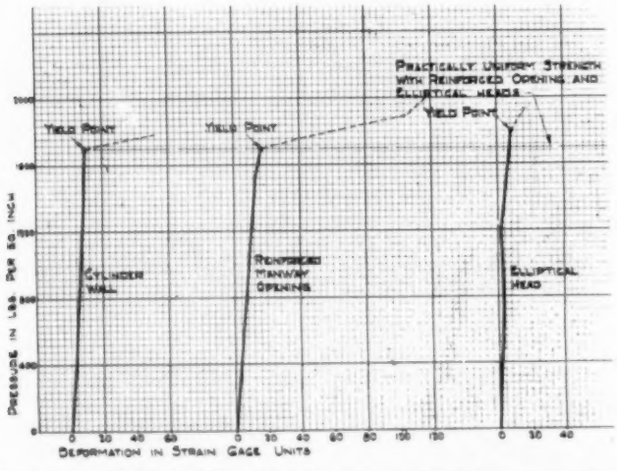


Fig. 2. Showing How Elliptical Heads and Reinforced Openings Tend to Make a Pressure Vessel Uniformly Strong Throughout.

But how can the industry insure good welding? Fundamentally, this question is not so difficult to answer, but most engineers asking the question approach it from a rather prejudiced standpoint. They are looking for a magic recipe, which, if followed to the letter, automatically will result in a good weld. "By going to a good welder for your product" might, therefore, sound like a facetious answer. Nevertheless, it is logical that if good welding can be produced consistently by some one, then he must know the secret of producing it.

To become a good welder involves a great deal of preliminary work, much patience, considerable expense, and long time. Those who have put forth such an effort for experimental work and development cannot be expected to divulge the knowledge they have so expensively obtained.

Only Physical Tests Tell the True Story

Many types of instruments are on the market for which are claimed the ability to tell a good weld from a bad one. Such aids as the X-ray and magnetic analysis may be useful

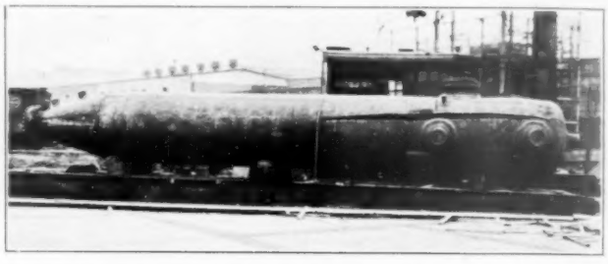


Fig. 3. This Large Vessel Was Operated at 900 Deg. F. and Almost 600 Lb. Pressure Continuously for Three and a Half Years, Then Tested to Destruction, With the Result Shown.

in the development of a new welding procedure to demonstrate the presence or absence of blow holes and similar defects. However, they can tell you nothing about the strength or other necessary properties of a sound weld. Only physical tests will demonstrate the strength, ductility, and impact values of a weld.

There is no reason why deposited weld metal cannot be taken out for test purposes from any part of a finished vessel intended for service. This is a very simple procedure, and one which will give the prospective user real facts as to the quality of his vessel. Perhaps such a requirement would also

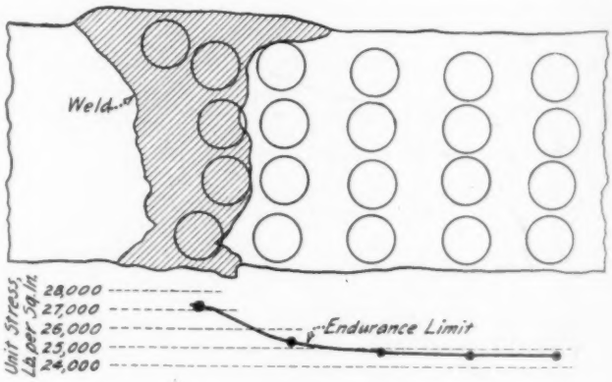


Fig. 4. Fatigue Test Results on Welded Plate, Showing Location of Specimens.

(Each specimen is ½ in. in diameter. The values plotted for the endurance limit were obtained by the rotating-beam test, ratio 1.0.)

bring about the most judicious care in the welding of the vessels, thus insuring the greatest possible protection for the user. The replacement of such weld or even small specimens of plate taken from a finished structure is a comparatively simple matter, and, if properly executed, will not in any way impair its strength or safety.

It is believed, however, that the user of welded products can be assured good welding if proper testing methods are

required of the finished product. Such methods not only consider the weld used in producing the structure, but the shape and design as well. For instance, the manufacturer who proposes to weld boilers should be willing to build a full-size vessel of maximum dimensions and test it to destruction. By so doing, he would prove the merits of his construction before presuming to produce vessels for this important service.

The fundamental way to protect the user in any type of vessel construction is to adequately test the finished product. Then, we do not care if the weld is "made of green cheese,"

Fig. 5. Precipitator for World's Largest Oil-Cracking Unit.
(Length 67 ft., inside diameter 10 ft., wall thickness 3⅛ in. Designed for a working pressure of 350 lb. per sq. in. at a temperature of 900 deg. F. Shipping weight, almost 400,000 lb.)

as long as it can produce certain desired qualities in the finished vessel—qualities which can be proved by tests and which, when attained, will insure safe operation in the service for which the vessel was designed.

Procedure Should Not Be Defined by Codes

A code specifying the exact procedure of welding is obsolete and fundamentally impossible, because there are many different ways of bringing about good weld results. Unfortunately, the A.S.M.E. Code Committee has as yet not recognized the full importance of testing vessels after completion. It is

Fig. 6. Welded Jacketed Autoclave.
(Capacity 1,000 gal., length 11 ft., inside diameter 6 ft., inner wall thickness 3 in., shipping weight, 42,500 lb.)

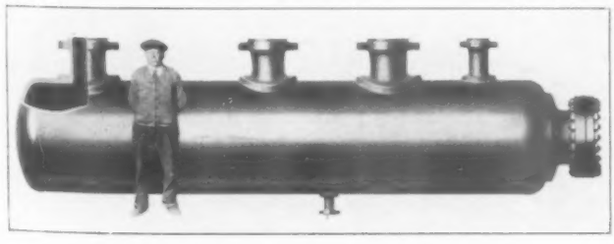


Fig. 7. Welded Steam Receiver-Separator.
(Overall length 19 ft. 2 in., inside diameter 40 in., wall thickness 2 in. Designed for a working pressure of 800 lb. per sq. in., in combination with a temperature of 750 deg. F. Approximate shipping weight, 22,400 lb.)

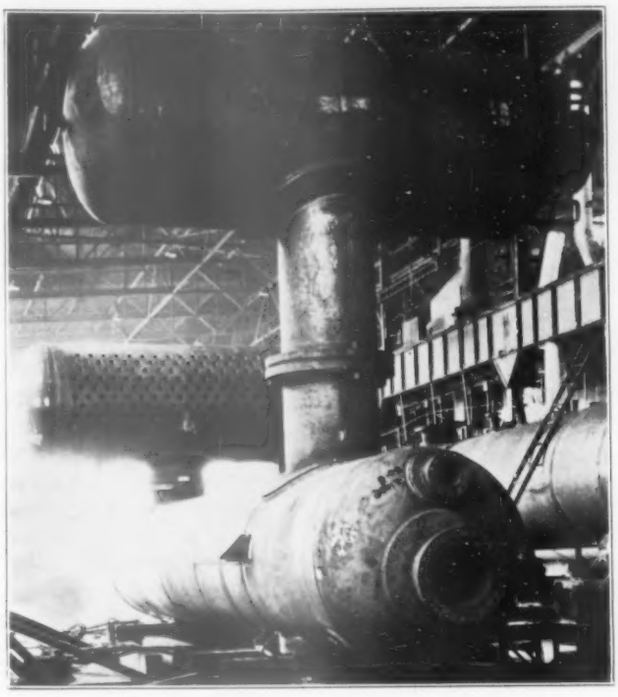


Fig. 9. Oil-Cracking Unit for Jenkins' Process.
(The longitudinal drum is 33 ft. long and the transverse drums each 17 ft. long. Weight 158,000 lb. Note that tube holes are bored through the weld in the rear drum.)

possible that the very welding procedure which will produce the best results may be eliminated by the adoption of set rules. If welding had been hedged in by such a code, then the company with which the writer is associated would not have succeeded in bringing arc welding to the state of perfection it has reached to-day in their plant.

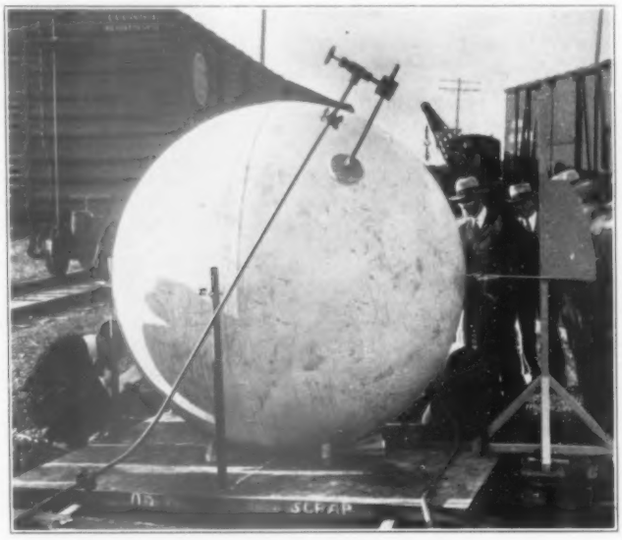


Fig. 9. Testing a Welded Sphere.
(This sphere, after going through a simulated train wreck, was mounted for the destruction test as shown, after being coated with limewash. During the test the limewash peels off first where the greatest stresses occur. Notice the Ames dials and the expansion meter.)

The vessel shown in Fig. 3 was constructed by welding nearly five years ago, and was put into service calling for continuous operation at 900 deg. F. and slightly under 600 lb. per sq. in. pressure. It was direct fired on the outside and the process involved a considerable corrosive action. After three and one-half years' service, it was withdrawn for test purposes. During the time of operation, corrosion had re-

duced the wall thickness in certain sections of the vessel from the original thickness of 2.5 in. to 1.6 in.

The test to failure gave a stress in the cylinder wall of 56,000 lb. per sq. in., which is above the specified strength of the steel when the vessel was built. It might be pointed out here that in the highly corroded sections of this vessel the welds had corroded much less than the plate proper.

This test is mentioned because it proves the point that severe testing after fabrication does not injure the structure. The vessel in question was subjected to our regular test procedure, involving repeated stress test, hammer test, and stressing the metal to 75% of its yield point.

Figs. 5 to 10 show a number of typical welded pressure vessels made by our company. These views bring out the fact quite clearly that designs, impossible by other methods of fabrication, can be built by welding.

Already some very enviable records have been made with the use of welding—convincing proof that it holds out excellent promises for the future. Structures have been made which are far beyond the possibility with any other method; vessels have been built twice as large and heavy as previous limits. Without arc welding, resulting economies would not have been attained.

ARMCO BROADCASTS TALK ON WELDING

One of the features of the program of Radio Station WLW, Cincinnati, is a series of band concerts by the Armco Concert Band. This band is composed of employees of the American Rolling Mill Company, Middletown, Ohio, and is nationally famous as an industrial band. Its contributions to the broadcasting program of WLW are very popular. As a part of each concert program, there is included a short talk by the "Iron Master," in which industrial subjects are explained to the radio audiences in a very interesting way. The program of the Armco Concert Band goes on the air at 10 p. m. eastern standard time, on Tuesdays. About midway in the one hour program, the Iron Master makes his usual popular lecture. The subject for the program of March 18th was "The Welding of Iron and Steel." Following is the text of the lecture:

Iron Master: Tonight, ladies and gentlemen, I am going to talk about the welding of iron and steel. It is a fascinating part of the iron and steel business, and a mighty important one, too, in today's scheme of things.

Welding, you know, was born out of the idea that metal parts could be joined by heat, quickly, firmly, and durably without bolts and rivets, and incidentally, without a lot of hammering and clattering noise. Although there are several different processes, oxy-acetylene welding and electric arc welding are the ones most commonly known today.

At first welding was given only menial tasks such as repairing broken and disabled machinery. It wasn't expected ever to grow up and do a man's size job.

Today, it has become a great loom that knits together the metal equipment and structures of the world. Vast networks of welded pipe literally web the continents; carry oil, gas and water to communities and industries everywhere. Millions of automobiles are being made with all-welded steel bodies; for good welds are strong. Building construction is being speeded up without the nerve-wracking din of riveting hammers.

Let's step across the street to a modern welding shop and touch the throbbing pulse of this mighty arm of industry.

Whoo! Isn't that a brilliant sight! See that vivid blue sheet of light * * * and the distorted shadows of the welders * * * What a weird picture it is. Let's go in and ask Walt, the shop foreman, to explain this fascinating work.

Hello, Walt.

Walt: Howdy, Mr. Iron Master.

Iron Master: Walt, I've brought these folks along to show them how welding is done. You might tell them something about the various processes.

Walt: All right, Mr. Iron Master. Really, it is all very simple. There are several different welding methods, among which oxy-acetylene welding and electric arc welding are the ones we use the most. Acetylene gas mixed with the proper quantity of oxygen produces a tremendously hot flame that is employed for cutting metal as well as for joining it. The cutting torch even severs metal under water. You see, the pressure of the gas and air prevents the water from extinguishing the powerful flame.

Electric arc welding is a process that has made rapid strides in recent years. With one of the new portable automatic machines, such as we have here in the shop, many of our production jobs can be done more quickly than ever before.

Iron Master: Thank you, Walt. Will you tell us what that busy fellow is doing over there with the long torch?

Walt: Certainly, Mr. Iron Master. He is building up an outside encircling weld on that big section of pipe. It is for a big water main of one of our large cities. We form the iron plates to pipe shape in special rolls, tack up the edges with temporary welds, and then build up the permanent weld both on the inside and outside of the pipe.

The fuel that produces this welding flame comes from those two bullet-shaped tanks. One contains acetylene gas, and other compressed oxygen. The two meet in the snout of the torch, the welder ignites them with a flint and steel device, and carefully regulates the pressure to generate the proper intensity of flame.

See that strand of wire he's holding in his left hand? That's a welding rod. The welder feeds it to the flame, which melts both the rod and the edge of the unbonded pipe. They fuse and become as one. The iron sets as fast as it cools, and you have a sound, solid union. However, the welder must watch his weld closely as he rounds the pipe. There must be no gaps, no air nor gas pockets, no hills nor valleys in the weld. It must be smooth, dense and sound. George, here, is a welder of long experience, and he can tell how the iron is bonding by the way it melts and fuses. He has the *feel* of it, as welders say.

Iron Master: Am I seeing things, Walt? Is that a mechanical man or a stray visitor from Mars . . . that fellow with the queer looking hood over his head?

Walt: Neither, Mr. Iron Master; it's Mac, one of our electric arc welders. He's wearing a special mask to protect his eyes from the bright rays and withering heat that arise from the automatic arc welding machine. But, let us go over, and I will explain to you how this machine operates.

Here, now, don't approach too close; and, above all, do not look at that dazzling light. It might injure your eyes. Take this hand-shield. It has lenses of colored glass which filter out the injurious rays.

Iron Master: Walt, what's the principle of this machine? How does it work?

Walt: Well, Mr. Iron Master, it's the old principle of the electric arc lamp. Instead of the two sticks of carbon, however, we use for most purposes an electrode wire of iron, while the other electrode is the metal to be welded. When the electric current is turned on, an arc is formed between these two and a terrific heat is generated.

With a bright blue flash and a shower of sparks the arc welder gets into action. Instantly, it melts both the electrode wire and the edges of the metal to be welded. As in the oxy-acetylene, or gas-welding process, the electrode wire and the iron plate become molten, fuse together, and finally cool in a firm, solid mass. A skillful welder, like Mac here, builds up a smooth, sound weld that holds tenaciously and endures.

Iron Master: Thank you, Walt. I am sure that we have learned a lot during our brief visit with you.

Walt: Thank you, Mr. Iron Master. It was a pleasure to show you how we weld iron and steel.

Iron Master: And now, folks, our time is up. Meet me here again next week at this time and we will resume our travels. Good night.

Economical Use of Welding Gas

Possibilities in the Saving of Acetylene and Oxygen by the Careful Use of Oxy-Acetylene Equipment

By Robert Moran

THE paramount factor in factory operation today is that of economy; it is the everlasting cry and demand from the highest mechanical officer to his subordinates that waste must stop, cost of operation must be cut; and the old familiar saying is broadcast again, "use up your old material by reclaiming what you can by the use of welding."

In this particular case the writer will take for his subject the railroads, because the railroads offer the best example for the subject under discussion. They are the greatest users of acetylene and oxygen in this country and it would probably surprise some readers if they were informed that the railroads spend many millions of dollars annually in the purchase of acetylene, oxygen, and oxy-acetylene equipment. So it behooves a heavy consumer such as a railroad to be constantly on the alert to prevent waste of acetylene and oxygen. Many articles and books have been written, and information has been given very generously by the manufacturers of acetylene and oxygen, on how to save by the careful use of oxy-acetylene equipment. This has helped to a certain degree, but there still is a waste.

Know the Equipment

There are several points to bring out which would help, not only to save acetylene and oxygen, but also increase the efficiency of the operator in the use of the torch. Before we can do anything efficiently we must know how to perform the work, and in this case we should be master of the tool we are operating. It is therefore necessary that the man who uses a torch for cutting or welding should receive instructions from a competent welder, a welding instructor or supervisor. He should be instructed on the assembly of the equipment, this to include the connecting of regulators to cylinders, hose to regulators, and hose to connectors on torch, all connections to be tight and leak-proof. If portable equipment, cylinders to be vertical and held in a position so as not to be hazardous to other workmen. After he is familiar with the set-up of the equipment he should be instructed in its care, such as, keeping his cutting tips clean, avoiding the possibilities of the seats of the cutting tip getting dented, and avoiding the practice of having too many splices in the hose. If the hose has been repaired too often, it should be replaced with new hose, as too many splice connections are apt to cause leaks and waste.

After the operator has been instructed in the lighting of the torch and the difference between a neutral flame and a carbonizing one, he should be instructed further along this line and told why the neutral flame is best and of the waste of gas and oxygen, time and material, which results from not being familiar with how to adjust gas pressures, so as to balance the acetylene and oxygen in order to secure perfect combustion and a neutral flame. "Excess of acetylene or oxygen is waste."

Standardize Tip Sizes

Great savings can be accomplished if the size of the cutting tip is standardized. The manufacturers of oxy-acetylene equipment have various-size tips to go with their cutting torches, and it seems to be the delight for some operators to secure the largest cutting tip they can get and use it continually on every cutting operation they perform; the bigger the flame the better they like it, and they use it regardless of the thickness of the piece to be cut.

Outside of cutting billets with the mechanically operated cutting torch, the thickest piece to be cut with the portable cutting torch is the locomotive frame. Let us say the average thickness or size is 5x7 in. With one popular make of cutting torch, it is possible to dispense with all sizes over the No. 3 size cutting tip. This will answer all cutting purposes in the railroad shops. No. 4 and No. 5 should not be used, as the No. 3 will meet all requirements and will effect a considerable saving in acetylene and oxygen. I admit that the larger-size tip can be used, but the occasion is very rare. Wrecking crews should be supplied with the larger-size cutting tips, as this expedites their work in cleaning up wrecks and derailments.

Watch the Pressures

Manufacturers of oxy-acetylene equipment could help the users of their products effect greater savings by designing regulators to meet the requirements of the user. In my dealings with various representatives of the oxy-acetylene companies, I found that they are anxious at all times to cooperate with the users of their products in helping to keep the gas and oxygen consumption at a low point; but they can do more, especially in the railroad field, if they would design regulators so that the operator could not get beyond the pressure point the regulator was designed for. In other words, if the average oxygen pressure for cutting operations in the large back shops was about fifty pounds for portable equipment, that is what the regulator should be designed for. Extra regulators could be carried in the tool room to take care of work requiring a greater pressure. This would prevent operators from shooting up the pressure to a point far beyond the average. In shops where pipe lines are used for gas and oxygen distribution, the pressure can be regulated in the manifold rooms; but with an installation of this kind there is danger of waste unless a maintenance man is appointed whose duties would consist of testing pipe lines periodically for leaks, repair leaks if any, and assist in maintaining acetylene generators.

Use the Service Men

There is one short cut to economies in weldfing and cutting operations which a good many firms overlook. Practically all manufacturers of welding and cutting apparatus and of oxygen and acetylene and other gases used for welding and cutting, keep service men on the job who are able and willing to aid customers in utilizing their equipment most efficiently and economically. These service men know better than any one else how many consumers fail to utilize their service to the fullest extent. They have been trained to make a complete check of the operating condition of every piece of apparatus and locate possible causes of waste. There is not one of them who cannot tell stories of torches and regulators returned to the factory for repairs that could have been made in a few moments by the service man, thus saving all the expense of packing and shipping, receiving, unpacking, and putting back into service, in addition to the factory charge for the repair. They can also tell stories of apparatus which should have been returned to the factory for repair which was fixed up by some mechanic in the customer's plant, and continued in operation at only a fraction of its real efficiency, resulting in waste very much in excess of the cost of the necessary factory repair. It is not unusual to find old equipment which has been abused or worn out still doing service, when it would be real economy to throw it away and install new equipment if it could not be repaired.

The majority of service men and salesmen who are skilled in giving service can present the facts in an understandable manner and enable the consumer to get more value out of the equip-

ment he has in operation. Very often, the man in charge does not give the service man a fair chance to do all he can, either because he is afraid that he will be coaxed to buy something, or because he is afraid that any lack of efficiency uncovered by the service man will reflect upon his own ability and judgment. Good judgment really consists in giving the service men a chance to serve.

Watch Gas Tanks Going Back

Gas producers are sincerely anxious to prevent wasteful use of their products, because they fully appreciate the fact that their own industry is injured by wasteful methods. When they find that among the empty tanks returned by their customers there is an occasional full tank and a number of partly filled tanks, they know that the customers who return this gas are paying more than they should for their welding and cutting operations; but sometimes it does more harm than good if the seller notifies the buyer of such an occurrence, especially in case such notice is given to the management. The management would criticize the welder or cutter or man in charge of stock, who in turn would resent the action of the seller and wait for a chance to make trouble for him in the future. There are few places where there is not a sufficient variety of work to be done so full use can be secured from the gas in partly empty tanks. It is up to the user to see that the gas is used, because the seller has these good reasons for hesitating to follow up cases where his product is returned to him. A good service man can always help a user to work out a simple checking system to avoid this form of waste.

Keep Equipment Clean and Serviceable

Another common cause of waste is poor supervision. Welding and cutting apparatus can be used with the greatest economy and efficiency only in cases where there is some one in charge of these operations who has taken the time to become thoroughly familiar with the apparatus and materials used. In too many cases there is too much left to the judgment of semi-skilled laborers, who even though they may be experienced enough to know that wasteful practices are being followed, hesitate to jeopardize their positions by criticizing what is being done. One of the most important sources of waste in such cases is the failure to keep the apparatus in good working condition.

Many times welding and cutting torches are returned to the factory for repair with the complaint that they will no longer work, and it is found that the only cause of trouble is obstructions in the tips. There is no way of telling how long such torches have continued in operation with these obstructions and how much gas and other material has been wasted by trying to get work done with an irregular and bad-acting flame before it was decided to have repairs made. A foreman or superintendent or master mechanic who had taken the trouble to become informed on the rudiments of welding and cutting would have on hand drills of the proper size to keep the tips clear, and would make frequent inspections to see that these drills were used immediately when it became necessary.

Tank vs. Generator Acetylene

As far as the acetylene consumption is concerned, there is some difference of opinion regarding the desirability of using dissolved acetylene as compared to using acetylene direct from a generator. No satisfactory set of rules for determining when each method is most desirable has ever been compiled. It is obvious, of course, that acetylene used directly from the generator should be considerably lower in cost than when it is shipped in the specially constructed containers which are required for the storage of acetylene under pressure. Some users do not want to have generators at all because they cannot use generators for every requirement. Others have gone into the subject more carefully and have found that they can make considerable savings by picking out certain operations for which they are able to use acetylene generators and make these devices save a good deal more than their cost annually. This is a subject which will bear a good deal of study by any large consumer.

Conclusion

It is not universally true that all users of welding and cutting gases are guilty of large wastes. The number of consumers who are wasting money is steadily decreasing, because in all kinds of industrial plants there is a tendency on the part of the management to keep these costs down as low as possible. However, where the problem has not received serious attention, it is probably a conservative estimate to say that 10% of the gas used could be saved by putting the following suggestions into effect:

(a) Encourage the salesman or service man to make a survey of operating conditions and make recommendations for increased efficiency.

(b) Arrange for the appointment of a conscientious and intelligent supervisor, preferably some one in an executive capacity in the plant, to maintain a careful check on the consumption of gas, and avoid as far as possible the return of tanks which are not empty.

(c) Adopt a system of regular inspection of all apparatus to make sure that every piece is kept at all times in good operating condition and that repairs are made immediately when any piece of apparatus becomes slightly out of order.

(d) Check all welding operations to make sure that the pressures used for each job are the correct pressures which will not involve waste, and that all operators are required to use the correct pressures at all times.

(e) Avoid the use of the oxy-acetylene torch for heating jobs which could be done just as well by some less-expensive method.

(f) Check all welding procedures to avoid using an excessive amount of welding in places where it will do no good.

(g) When in doubt, get expert advice.

CHICAGO SECTION HEARS DISCUSSION OF ECONOMY PHASES OF WELDING

"Arc Welding and Economy," was the title of the paper read before the American Welding Society, Chicago Section, on Thursday evening, April 3rd, by J. H. Babcock, General Foreman of the Barber-Greene Co., Aurora, Ill. The speaker developed the subject from two viewpoints: First, the possibilities of securing economy by the use of arc welding in the factory, and in particular, by finding what parts of products can be fabricated more economically by welding than by casting. The other phase of the subject of economy is the matter of working out procedures and designs and the construction of jigs which shorten the labor period and minimize the amount of material required to do a satisfactory job. The talk was illustrated by lantern slides showing the use of welding in a number of the products of the Barber-Greene Co., and the speaker furnished detailed information regarding comparative costs on various jobs, when handled by different methods.

TEACHERS HEAR TALKS ON GAS WELDING

Talks and motion pictures on oxy-acetylene welding were given before a group of over 100 Chicago technical high-school teachers on March 21st to fulfill a desire on the part of the teachers to learn something of the process and its possibilities. The Union Carbide & Carbon Corp. presented to the teachers some fundamental information regarding the process of welding and of oxygen manufacture. The speakers were J. I. Banash, consulting engineer of the International Acetylene Association, and Fred G. Outcalt. Various welded articles were exhibited for inspection, and a lecture and demonstration on liquid air added further interest to the meeting.

This was the first of a series of meetings to be held by the teachers of the Chicago technical high schools to acquaint themselves with the basic technical industries of our nation. A committee of teachers is arranging the meetings, and the oxy-acetylene welding industry was selected as the first to be studied.

Design Theory of Butt and Spot Welders*

High Heat, Quickly Secured, and Held for a Short Duration Only, Results in a Fine Grain Structure at and Near the Weld With Total Absence of Burned Metal

By Byron T. Mottinger†

RESISTANCE butt welds are made between two pieces of metal held in dies as shown in Fig. 1. Butt welding comes under two classifications. The older type is known as a "straight butt weld," or frequently called a "resistance butt weld." It is produced by clamping the pieces to be welded between the dies, forcing the pieces together with some pressure, and then applying the welding current. The area of contact, at this stage, is naturally quite restricted, and the small area is soon heated, which flattens down under the pressure and permits other areas to come into contact, and likewise become heated. As the hot metal has a very much greater resistance than the cold metal, there is a dispersing factor introduced which tends to equalize the temperature over the entire surface of the area of contact. The current is applied sufficiently long to permit the joint to become heated to the plastic state, at which time the two pieces are forced together vigorously, and an upset is produced as shown in Fig. 1. This type of weld depends upon the inherent resistance of the metal being welded and likewise upon the resistance of the contact at the joint, and hence has been termed a "resistance butt weld," in order to differentiate between it and the type of weld shown which is generally spoken of as a "flash butt weld."

Flash Butt Welding

The difference between the flash butt weld and the resistance butt weld lies in the fact that in the case of the former the welding potential is applied to the pieces before they are permitted to come into contact. Immediately upon making

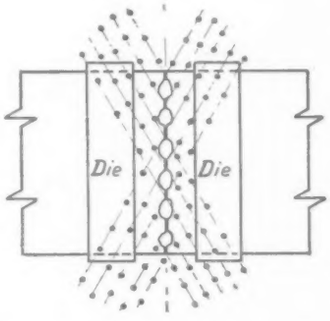


Fig. 1. Illustrating Flashing Action in Butt Welding.

contact there is a violent arcing or sparking between the pieces, volatilizing and throwing out the metal about the contacting areas. This action, called "flashing," continues as long as the pieces are made to approach, one toward the other. The violence of the flashing increases with the increase in the speed of approach, assuming that there is sufficient energy to cope with the demand. The flashing period covers two distinct stages. The first stage is usually accomplished under uniform speed of approach, and continues till complete normalcy of areas is secured between the opposing ends to be welded. As soon as uniform flashing over the entire area is secured, then acceleration of the parts becomes necessary. The acceleration causes more metal to be volatilized and thrown out, and this in turn increases the temperature of the ends to be welded. The acceleration plays another very important part. It prevents the heat from running back toward the welding dies, and into the unheated sections, which in turn governs the nature of the upset upon completion of the weld.

The steps, then, in making a flash butt weld are as follows: Clamp the pieces under the dies, apply the welding electromotive force, cause the pieces to approach at uniform speed until normalcy of areas is secured by flashing, then accelerate the speed of the approaching pieces up to such a point where white heat and plasticity are assured, finish with a quick, short upsetting blow. This process will insure the very best type of weld possible to secure, having a strength equal to the original metal and the very least possible upset. This covers the two essential requirements of all commercial mass-production welds.

Up to the present time there has not been devised any scientific means for determining exactly what is happening in the flashing zone. From observation it appears that for a

Fig. 2. Typical Butt-Welding-Machine Circuit.

given speed of approach of the metals to the flashing zone, the higher the welding voltage is held, the larger will be the flashing particles evolved, carrying with them increased heat and violence; while with decreased voltage, the sparks will be finer, not so hot, and they will be emitted with less violence. This action is well illustrated in practice, when butt welding thin sheets, such as No. 20 gage. By permitting the speed of flashing and degree of upsetting to remain constant, and varying only the voltage from time to time, it has been found that pin holes will show up in the seam when excessive voltage is applied. This shows that the violent, volcanic action taking place along the seam has torn out pieces of plastic metal, leaving the edge ragged and toothed to such a degree that the push-up was not able to fill the void spaces made by the violent flashing. However, increasing the degree of upset will in most cases fill up the pin holes again.

Before the effect of increasing the voltage across the weld, comes the further and more important consideration of increasing the speed of acceleration of the metals into the flashing zone, along with the problem of securing the proper degree of acceleration. It has been shown by experimental tests that there is no practical limit to the magnitude of the applied welding voltage advisable to use, so long as the proper degree of acceleration is maintained, and so long as the increased current demand does not produce burning under the dies. In fact the major problem of flash-butt-welder design lies in the need of coordinating the maximum voltage with the maximum degree of acceleration of the metal into the welding zone.

Electric Power Distribution in Welder Circuit

Before proceeding further with the discussion, it is necessary at this time to make a study of the power division of a

*Presented at the Winter Convention of the A.I.E.E., New York, N. Y., Jan. 27-31, 1930.
†The General Welder Company, Akron, Ohio.

typical butt-welder circuit. A diagram of such a circuit is shown in Fig. 2. Suppose the cross-section area of steel bars *A A* to be 1 sq. in.; that the specific resistance is seven times that of pure copper; that the length of bars *A A*, between dies *B B*, is 1 in.; that the length of the welding circuit, external to dies *B B*, is 49 in.; and that the area of cross-section of copper parts *C*, *D* and *E* is 7 sq. in. (that is, seven times the area of the steel bars). With the above proportions, there is, therefore, just the same *IR* drop in the external-welding-circuit copper, as there is in the bars between dies *B B*.

But since in practical designs there are introduced into the external circuit from six to nine electrical joints, all very difficult to make efficient, it is not an infrequent thing to find welding machines where the loss external to the dies is considerably more than the loss internal to the dies. This is especially true if the die contact resistance between die and weldable material be counted in with the external resistance, as is usual. With this consideration, many cases are to be found where the internal loss is but 30 per cent of the total welding circuit. This means that a welding machine requiring 100 kw. to make a certain weld, will have a loss of 70 kw. in the external welding circuit, and only 30 kw. loss in the weldable steel between the dies.

The internal loss in the steel between the dies is caused by the IR drop in the steel, and the counter-e.m.f. of the flashing zone. (Whether it is correct to speak of the drop in the flashing zone as a counter-e.m.f. may be open for criticism. It seems to act like the carbon arc, and has so been considered.) The magnitude of the loss cannot be definitely stated, since a number of variable quantities enter into the problem. The current density is a variable; the specific resistance of the steel varies with its make, and it increases with its temperature; while the counter-e.m.f. of the flashing zone is dependent upon the initial e.m.f. impressed, and upon the electrical characteristics of the balance of the circuit. In general, however, approximately ½ volt per inch of length is required to drive welding current density through steel. The counter-e.m.f. of the flashing zone may be taken, under average conditions, at ½ volt, so that the sum of the resistive drop in 1 in. length of steel, the counter-e.m.f. of the flashing zone, and the die contact, represent approximately 2 volts. If this internal loss represents 30 per cent of the total resistive drop, there will be required an initial impressed e.m.f. of 6.7 volts to overcome the total resistive drop. (The reactive component is not taken into consideration at this time.) The above relations may vary over a wide range, depending upon the design, but in general they will be found in practice to lie somewhere close to the above figures, when taking into consideration only normal and average applications of present welding machines.

To the layman it might appear from the above considerations that resistance butt welding presents a very inefficient method of applying electrical energy, when it is understood that of the 30 per cent energy represented between the dies, only 7½ per cent is used to create or generate the heat in the flashing zone (½ volt is 7½ per cent of the 6.7 volts required to overcome resistive drop), or, in other words, out of every 100 kw. consumed, but 7½ kw. appears as desired and efficient heat at the welding line, while 92½ kw. is consumed in overcoming unavoidable resistance of the balance of the welding circuit. However, in spite of the apparent inefficiency of the welding machine, it stands today as an accomplished fact that resistance butt welding is the cheapest and most rapid method, producing the most nearly perfect results of all welding methods applied to mass production. An automatic power-driven flash-pipe-butt-welding machine welds a 12-in. standard gas or oil line pipe in 7 sec. and consumes 2.7 kw. hr. of electrical energy. This machine produces 40 such complete welds per hour and the machine requires five men in its operation, an average of eight welds per hour per man, the cheapest and most efficient method yet devised for welding together lengths of pipe.

Steadying Effect Derived From External Resistance

To electrical engineers familiar with the regulative effect of resistance in series with the old-time arc lamp, the external losses in the butt-welding machine can be largely ameliorated on the grounds of the benefit derived from the regulative effect of external resistance. Take for example an arc operated at 10 amperes, through an external series resistance of 15 ohms, from a 220-volt circuit, having a normal counter-e.m.f. at the arc of 70 volts. If the carbons are pulled apart to a point where the current is cut down to 8 amperes, the drop in the external resistance will be cut from 150 volts to 120 volts, leaving an additional 30 volts to be consumed by the arc, or a total of 100 volts at the arc with the 8 amperes flowing as against 70 volts with 10 amperes flowing. This means that a reduction of 20 per cent in current flowing has increased the

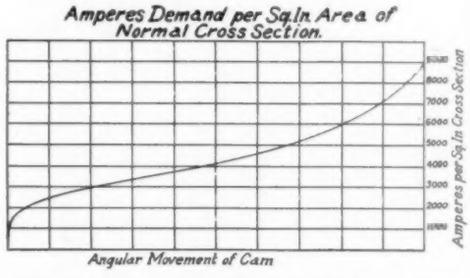


Fig. 3. Graph Showing Average Current Density in Flashing Zone, From Beginning of Flash to Upset.

voltage across the arc by 43 per cent. Hence the stabilizing action of resistance in series with the arc becomes apparent.

In exactly the same manner, external impedance in a welding machine becomes an important regulative factor in stabilizing arcing in the flashing zone. In practice, however, it is seldom found necessary to purposely build external impedance into a welding machine, for under the most favorable conditions of design it is usually sufficiently high. This is especially true of the reactive factor, and every precaution should be taken to cut this factor to the least possible amount. This can be accomplished in a great measure by paralleling as closely as possible the main secondary leads, and avoiding any interlinkage of this circuit with unnecessary parts which will set up a magneto-motive force opposed to the impressed e.m.f.

The power factor of butt-welding machines always comes up for consideration. It varies over a wide range, even as wide as the range of application of the machines, ranging anywhere between 45 and 75 per cent. If an average figure were to be hazarded it might be set at 65 per cent. The magnitude of the power factor is not the most important consideration on the part of the designer. It is the power engineer who is most concerned with power factor. The duration of the maximum peak load of the welding cycle is so short, being but a few seconds in the majority of applications, that neither the peak load nor the power factor is as objectionable as they have been thought.

It is the universal experience of welding-machine engineers, as they go about the country applying machines to industry, that where the nature of the machines is the least known, there is where the power engineers are the most skeptical of their effects to power lines. For example, a welding machine load is welcomed in Detroit by the Detroit Edison Company as much as any other kind of load, and there is possibly no place in the world where a power company serves more welding machines totaling a greater kilovolt-ampere load.

A study of the current densities found in the normal area of the flashing zone shows that the density does not vary over such wide limits as might be supposed. Of course, if

the study is extended to include the beginning of the flash, before normalcy of opposed areas is established, and before normal flashing is established, then the current densities as applied to the whole area vary from zero to a maximum of approximately 9,000 amperes per sq. in., the latter value being that just at upset, and being dependent very largely upon the total impedance of the closed circuit. However, if the study be confined to the densities in the flashing zone, only after normalcy of flashing area has been established, the limit of the values is found to lie between 4,500 amperes per sq. in. and 7,500 amperes per sq. in. as the upper limit. That is to say, with any density much below 4,500 amperes per sq. in. of weldable steel, flashing will be very feeble, unproductive of heat, while with a value of current density approaching 7,500 amperes per sq. in. of area of the flashing zone, a very violent flashing will take place, productive of incandescence, and representing in every way the upper limits of current density. If a fair average value is sought, it may be taken at 6,000 amperes per sq. in. of cross-section of weldable area. The curve in Fig. 3 shows the range of progress of current density, from the initial flash to the upset.

Power Required Per Unit Area

From the above considerations of the regulative effect of resistance in series with both the arc lamp and the flashing zone of a welding machine, it is apparent that a small increment of increase in the current density is accompanied by more than a direct proportional increment of increase in the necessary impressed e.m.f. It is apparent, therefore, that the power required to butt weld steel as well as other metals, cannot be expressed with any degree of accuracy in terms of kilovolt-amperes per square inch, with the expectation of the figure holding good for a range of welding machines having different electrical characteristics. While the current density, as for example with steel, does not vary over such wide limits, the voltage required to produce this density does vary over

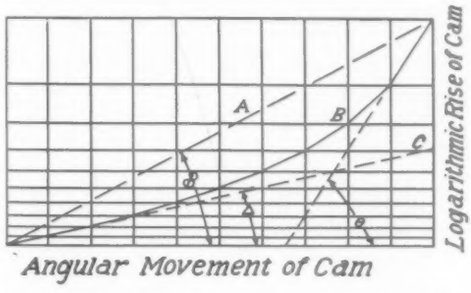


Fig. 4. Graphs of Two Butt-Welder Flash Cams.
(Cam *A* produces uniform motion. Cam *B* produces logarithmic acceleration.)

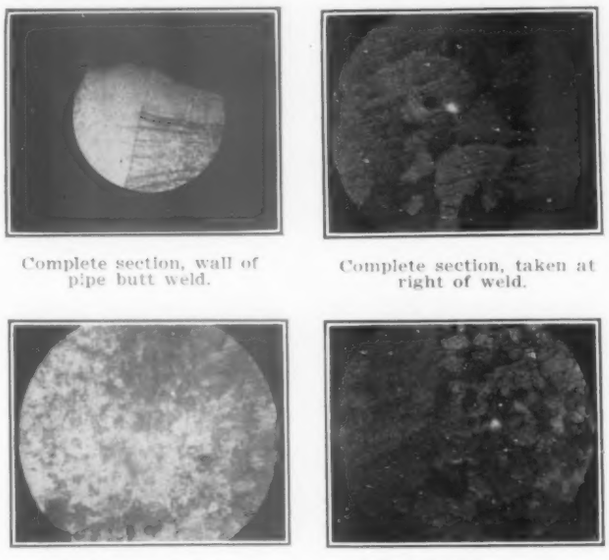
a considerable range, depending entirely upon the electrical characteristics of the welding machine. The kilovolt-amperes required to weld a given section is dependent upon time. So there are three variables entering into the problem of power required per unit area—namely, current density, voltage, and time—and these three variables do not, as repeated tests have shown, vary by the law of direct or inverse proportions. This statement is especially true of the more recent highly intensified acceleration of the flashing cycle where areas of cross-section approximating 16 sq. in. are welded by automatic power welders in, say, six seconds.

The result of feeding metal into the flashing zone of a flash butt weld is similar to the results obtained by feeding fuel into a furnace. If the furnace is supplied with sufficient oxidizing means, the faster the fuel is fired into the furnace the more heat is generated. This heat will show up in one or both of two ways. It will appear as increased temperature, or it may appear as a large quantity of heat units liberated, or, as is more probable, it will appear both as increased temperature and as a greater quantity of heat. Similarly with a flash butt weld, if sufficient welding voltage is maintained, the faster the metal is fed into the flashing zone the greater will be the heat set up. This will show up as increased temperature and also in the larger quantity of heat units produced, part of which is carried away by the flashing materials thrown off, part of which is carried away by convection due to the higher temperature gradient, and a small part of which is directly radiated away.

The critical part of the flashing cycle is usually found to be at the beginning. If sufficient energy is available to start the flashing at uniform speed until normalcy of areas is presented, there is little danger from cessation of flashing, due to freezing at points later on in the flashing cycle.

Design of Flashing Cam

The flashing cam used in the average automatic butt welding machine seldom has an acceleration greater than 3 : 1. In a few extreme instances the acceleration approaches 3½ : 1. It has recently been found that a very much greater ratio



Complete section, wall of pipe butt weld. Complete section, taken at right of weld.

Taken in the weld. Taken at left of weld.

Fig. 5. Photomicrographs of Butt Weld in Pipe.

of acceleration is possible. The larger ratio is not only possible, but very desirable, if not necessary. In Fig. 4, are shown graphs of two cams, *A* and *B*. Cam *A* is constructed with equal increments of rise for equal increments of angular movement. In other words it is a straight line, forming an angle β with the horizontal base line. Cam *B* is a logarithmic curve. It is constructed so that the tangent θ is approximately eight times greater than the tangent $\triangle$, thus producing a final acceleration eight times greater than the initial speed. The initial movement is taken at the same maximum speed, insuring against freezing. The tangent of angle $\triangle$ in this graph is 0.192, while the tangent of angle β is 0.5151. Therefore if cam *A* is to replace cam *B*, the angular velocity of cam *A* will have to be slowed down in the inverse ratio of 0.192 : 0.515, or in the ratio of 2.68 : 1. Therefore from a standpoint of time, cam *B* will perform a given flashing cycle in 7½ sec., while came *A* will require 20 sec. to perform the same flashing cycle.

The saving in time by the use of the form of cam *B* over that of cam *A* is only a part of the benefits derived by its use. The saving in time is in fact only incidental. The benefits lie in the shortened time of the flash produced by the high acceleration of the metals into the flashing zone, which in turn produces the maximum degree of temperature in the shortest possible time, providing the least possible "run-back" of heat.

From these two conditions are derived two important results. The first is, that maximum degree of heat with momentary duration positively insures a fine grain structure in the weld. It further insures a thin lamination effected by the weld, in most cases not exceeding 0.001 in. in thickness. And in the second place, a short "run-back" of heat insures a small swelling at the upset. The former condition, a fine grain structure in the weld, insures a tensile and bending strength equal to or greater than the virgin metal; while a short, quick upset insures the least possible labor in removing the excess material.

The photomicrographs in Fig. 5 are those of an automatic pipe butt weld made in six seconds, the wall of the pipe being ⅜ in. in thickness. Graph *A* of Fig. 5 is of low power and is intended to be a bird's-eye view of the whole section. Graph *B* is of higher magnification, showing the virgin structure of the pipe to the right of the weld; graph *C* is of the same magnification, showing the grain structure in the weld; while graph *D* shows the grain structure to the left of the weld. Hundreds of photomicrographs have been made of this type of weld, and all show the same fine grain structure in the

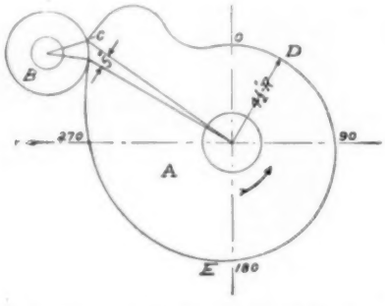


Fig. 6. Typical Combination Flash-and-Upset Cam, Used for Small Cross-Sections.

weld. This condition can seldom be secured by slow flashing and upsetting.

The time required for upsetting is as important as the degree of acceleration and the time required for the flashing cycle. Here again, tests have shown that the quicker and sharper the upset action has been, the more complete and perfect has been the fusion in the weld. If the upset is made slowly, it must then be forced to a much greater degree to form a good weld, and the weld will be accompanied by an objectionable amount of squeezed out material. It is evident from a study of welds made with varying lengths of time in upsetting, that the instant the abutting pieces touch, and flashing is stopped, the temperature drops on the inner surfaces of the weld. The high

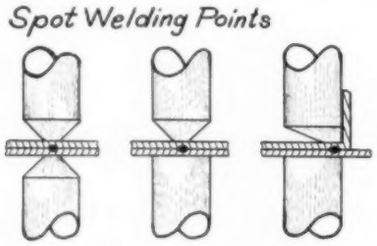


Fig. 7. Typical Spot-Welding Electrodes.

degree of temperature necessary for fluidity and perfect fusion evidently falls the instant flashing ceases, and it does so whether the welding current is held on during the upset cycle or not. In automatic pipe butt welding, where areas as large as 16 sq. in. are being welded, it has been found that if the upsetting can be done in 0.1 sec. or less the required grain structure in the weld is preserved.

It is difficult to design a combined flashing and upsetting cam to weld the larger areas. Two problems are presented. The first problem is to be able to make the comparatively slow-moving flashing cam perform the upset in the short space of time, and the second problem is to be able to design this slowly moving cam so it can exert the necessary foot-pounds required to upset the weld. Take for example the combined flash-and-upset cam shown in Fig. 6. If such a cam is designed to flash and upset 3 sq. in. of steel, it may be found advisable to make the minimum radius about 4½ in. Permitting an idle zone from *O* to *D*, the active flashing portion of the cam (extending from *D* and *E* to *C*) will cover about 270 deg. If the cam is provided with ½ in. of upset at *C*, and the cam roller is 4 in. in minimum diameter, the main cam will have to turn approximately 5 deg. to complete the upset. If the upset takes place in 0.1 sec., it will require 5.4 sec. to

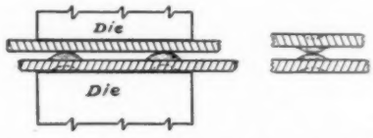


Fig. 8. Methods Used in Projection Welding, Showing Electrodes.

complete the flashing cycle (270 deg.), or 7.2 sec. for the cam to make one complete revolution. The cam chosen probably illustrates quite fairly average design proportions for a combination flashing-and-upsetting cam used on welding machines up to 3 sq. in. capacity.

Two Cam Systems Required for Large Sections

However, for welding considerably larger sections, even three or four times that of the above, or where for example an area of 36 sq. in. must be flashed and upset automatically, the above combination cam can no longer be made to meet the necessary requirements. Heretofore all such sections have been flash butt welded by hydraulic power. To accomplish this by motor power, fully automatic, it has been found necessary to introduce into the welding machine two systems of cams. One system is confined to the flashing cycle, and the other is confined to the upsetting cycle. The flashing cycle requires, inherently, from fifty to one hundred times more time than the upsetting cycle. At the same time it requires only a fractional part of the energy required for upsetting. When the two systems are used the upsetting cam is timed or synchronized with the flashing cam. With this arrangement the speed of the flashing cam can be varied at will, or

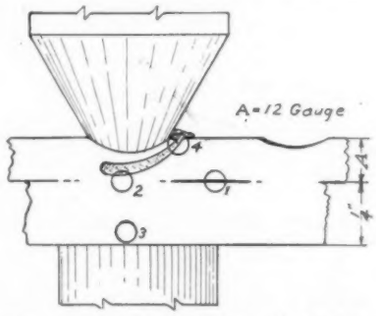


Fig. 9. Plat of Photomicrographs in Typical Spot Weld.

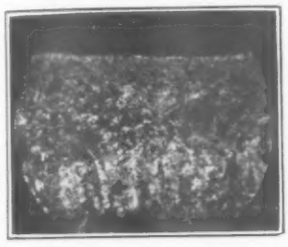
the amount of the flashing cam permitted to become operative can be varied without affecting the time of the upset cycle. The amount of flashing, of course, is dependent upon the relative time that the upset cam functions. Two large butt-welding machines have been constructed along this line, one welding up to 16 sq. in., and the other welding up to 36 sq. in., and both have proved beyond doubt the correctness of the principle. (This feature is being protected by patents.)

Spot welding, while not so old as butt welding, has now been practised for many years, and it is accomplished essentially by the use of two copper electrodes, variously formed as in Fig. 7. The electrodes thus formed are on opposite sides of overlapping sheets, and a powerful current of short duration is passed from electrode to electrode, passing through

the sheets. The magnitude of the current is so proportioned that the sheets are heated to plasticity, whereupon an extra force is exerted upon the sheets by the electrodes and they are forced together and thus welded. The area thus welded is usually small, ranging from ⅛ in. in diameter up to extreme diameters of about ½ in., depending upon the plate thickness, quality of plate, etc.

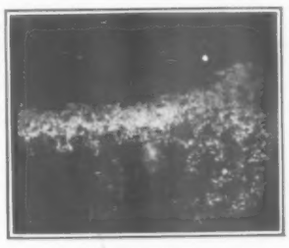
The current density required for welding by this method varies much with the thickness of the sheets, quality of the sheets, diameter of the points, and the time of duration. For a rough comparison between spot welding and butt welding a factor of 20 might be taken as giving fair average conditions. That is to say, a current density of about 120,000 amperes per sq. in. of spot weld area is required. This figure can be used only for rough calculations, and a closer figure can be given only by one experienced in these requirements.

An improvement over the old method of spot welding has come into use, known as projection welding. In this case plain flat electrodes are used above and below the sheets to



Showing virgin sheet at position (1) in Fig. 9.

Showing effect of current, position (3) in Fig. 9.



Showing effect of current, position (4) in Fig. 9.

Fig. 10. Photomicrographs of Flash Spot Weld.

be welded, as in Fig. 8. Before welding, one or both of the plates are projected by a forming die. At the left in Fig. 8 only one plate, the lower one, is projected, while at the right both plates are projected.

Heat Control in Spot and Projection Welding

The essential thing to secure in both spot welding and projection welding is proper heat control. A large majority of these welds either show burning or they are overheated to such an extent as to show a very poor grain structure. Fig. 9 shows diagrammatically a typical weld between a No. 12 gage polished cold-rolled sheet and a ¼-in. cold-rolled sheet. The upper electrode was pointed, while the plates rested upon a flat lower electrode, both shown in part only.

Graph *A* in Fig. 10 was taken at (1) in Fig. 9. It shows the longitudinal laminations caused by rolling the sheet. The upper dark band is the small open space between the sheets darkened by the copper etching solution. Graph *B*, taken at position (3) low down in the sheet next to the lower electrode, shows overheating, poor arrangement of grain structure, and even burning. Position (2) was very similar to position (3), and for brevity has been omitted. Graph *C* of position (4), taken just under the upper electrode, shows the cooling effect of contact with the upper electrode by the band adjacent to it, leaving the rolling laminations plainly visible. Overheating is shown lower down, however, and in the extreme lower corner burning is in evidence.

The recently developed methods of "flash spot welding," and "flash projection welding," entirely eliminate all tendency toward burning, and insure a fine grain structure, accompanied by an entire rearrangement of crystals of the most favorable nature. The photomicrographs in Fig. 11 show typical flash projection welds made between two 12-gage cold-rolled sheets. Three of these photographs show the same weld, using three different powers of magnification. These three were taken

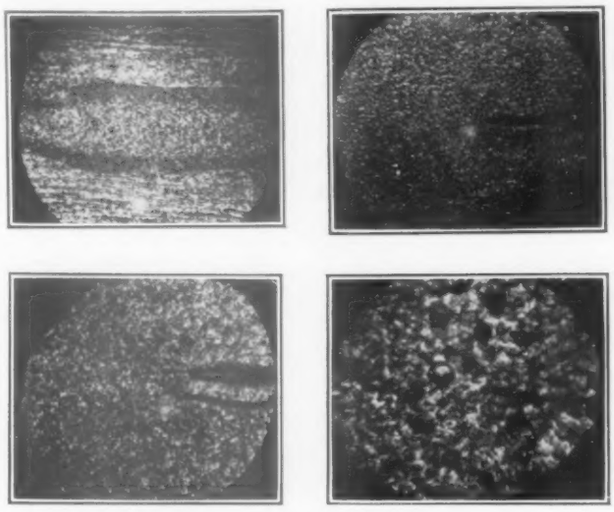


Fig. 11. Photomicrographs of Typical Flash Projection Welds With Different Powers of Magnification.

without changing the axis of the field of the microscope. The microscope was focused at the very extreme edge of the weld. The curved shape of the projection is plainly visible.

Flash spot welding and flash projection welding accomplish in this field exactly what the rapidly accelerated flash and quick upset accomplish in the field of butt welding. Both are dependent upon the theory that high heat, quickly secured, and held for a short duration only, will invariably produce a fine-grain structure in the weld.

The author desires to thank Mr. Paul C. Zarrs, Chief Engineer, The General Welder Company, for valuable suggestions, and for assistance in producing the photomicrographs herewith shown.

FIFTH ANNUAL WELDING SYMPOSIUM

The following program was scheduled for the Fifth Annual Welding Symposium, held at Lehigh University, Bethlehem, Pa., April 11th:

Demonstrations and lectures on Methods for Testing the Soundness of Welds. For example, X-Ray Penetrative Methods, by H. H. Lester, of the Watertown Arsenal; Sperry Electrical Testing Aparatus, by a representative of the Sperry Development Co.; and The Stethoscope Method, by a representative of the Linde Air Products Co.

Demonstration of welding by projection of the crater and rod and flame on a screen in a magnified form, by Prof. Frederick Creedy, of Lehigh University.

Demonstrations of welding and testing of welds, as follows: Butt, spot and thermit welding. Automatic electric arc, hand electric arc, and atomic hydrogen welding. Gas welding of airplane materials, including duralumin, chrome-molybdenum steel, mild-steel tubing, aluminum sheet, Stelliting of airplane tail skids, etc.; also cutting with the oxygen torch. Testing by longitudinal tension, bending, etc., of the specimens inspected for soundness by all of the three methods before-mentioned.

Resistance Welding, by M. L. Eckmann, recently welding supervisor of the Ford Motor Co., followed by discussion. Also presentation of the results of tests of welds completed during the afternoon in the Fritz Engineering Laboratory.

TRANSFER OF ELECTRODE METAL IN THE WELDING ARC*

Although the processes occurring in the welding flame of the acetylene-oxygen burner are already quite well known, comparatively little has been determined concerning the behavior of the metal in arc welding until very recently, especially concerning the transfer of the metal from the electrode to the object to be welded. Attempts have been made to visualize the transfer of the metal by means of photographic equipment; however, only rarely could a drop of metal be photographed, owing to the exceptional rapidity of the processes in the metal arc.

Greater success was assured, however, when attempting to study the process by means of the oscillograph; deductions could then be drawn from the behavior of the arc-voltage and arc-current curves in relation to the duration and size of the drop of metal. For at the moment when a drop of metal is transferred, a short-circuit takes place, the strength of the current increasing to the maximum value for the welding apparatus and the voltage dropping to zero, where it remains until the drop of metal has been transferred and a new arc has formed. Yet, in spite of the great sensitivity of the oscillograph, it is not yet capable of following up completely the exceptionally rapid alternating processes.

Then occurred the idea of filming the arc, provided many pictures could be taken per second. In consequence, the welding arc was photographed in 1927, upon a suggestion by Dr. A. Hilpert. This work was done at the Experimental Station for Welding Technique at the Berlin High Technical School. An apparatus developed by the film expert engineer, Thun, was employed, which at that time was capable of taking 800 pictures per second. But even when the completed film was slowed down in projection to 40 times, it was impossible to show how the material transferred from the electrode to the object being welded, owing to the extreme brightness of the arc; it could be seen that the arc still jumpd around rather lively.

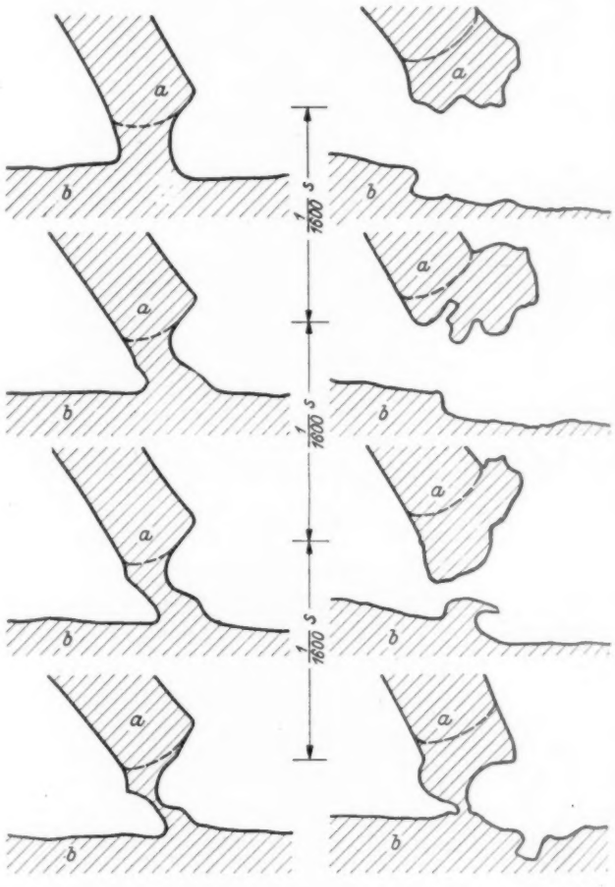
Meanwhile, in America motion studies had been made of the welding arc upon film which was highly sensitive to red and which was placed behind strong red filters to filter out the red, the heat radiation during the transfer of the metal being utilized in making the photographs. However, since a sufficiently long exposure to light had to be considered, only about 60 pictures could be made per second; hence, in projection, the film could be slowed down only four times. For the first time a transfer of metal could be observed in using the American method, which, however, lacked in distinctness in form and behavior, especially because of the excessive rapidity of the process.

Meanwhile Thun had developed a new method permitting the taking of as many as 4,000 pictures per second. In this method the transfer of metal was made distinctly visible by placing the welding arc between the camera and a source of light stronger than the light from the arc. In this manner a shadow picture, or silhouette, was obtained of the metal being transferred.

The usefulness of this new method was indicated in a few test exposures. As a result, the Society of German Engineers, with financial aid obtained from their Special Committee on Welding, conducted a systematic investigation of the transfer of metal. As a start it employed bare electrodes low in carbon content and attached to the negative pole. Welding was done with an automatic welding machine to exclude the possible uncertainty of welding by hand. Simultaneously with the filming of the transfer of metal drops, the tension and the intensity of the welding current were recorded by means of an oscillograph, and also the voltage of the arc, 50-cycle current being used. By comparing the oscillograph records with the pictures on the film, it was possible to follow the transfer of the individual drops in relation to time, to the voltage and intensity of the welding current, and also to the duration of the arc.

By varying the voltage while maintaining the intensity of the current constant, and by varying the intensity of the current while maintaining the welding voltage constant, the operators could obtain a mental picture regarding the most suitable voltage and intensity of electric current for a given electrode, and especially also regarding the relation of duration of the arc to the duration of the transfer of the drop of metal; this knowledge is important for obtaining proper preheating and depth of burning.

By this method the operation is made independent of the rapidity of passing the strip of film and the oscillógram through the projector, as the distance from point to point of the curve of the alternating current is taken as 1/50th second; from this information can be figured the length of duration of the drop of metal in transfer, which is shown by the black lines at the zero line of the other curves.



Shadowgraphs of Transfer of Molten Metal From Electrode Tip to the Weld Seam.

(The four views on the left show a thread-shape transfer, and the views on the right show a mushroom-shape transfer. Each consecutive picture, reading from top down, represents an interval of time of 1/1600 second. **a**=electrode. **b**=seam being welded.)

About 3,000 drops were recorded in the above experiments, of which the longest had a duration of about 1/7th second and the shortest of only about 1/2000th second. The films were taken at a rate of about 1,600 to 2,400 pictures per second; therefore the pictures could be slowed down about 130 times when projected. As a result, even the most rapid processes became still quite visible to the eye.

There were determinable principally two shapes of metal drops, the thread shape and the mushroom shape. In the former, the metal transfers in the shape of a thread without thickening of the electrode point, and in the latter there is a more or less intense thickening of the electrode point where the drop dances several times back and forth until finally it transfers to the material to be welded.

The illustrations show the rapidity of the transfer processes. The shape changes considerably within 1/1600th second; hence it is necessary to operate with a very large number of pictures when investigating the transfer of the working metal in arc welding, according to A. Hilpert, the author.

*Translated and Abstracted from the VDI-Zeitschrift, 1929, 73, 23, pp. 798-799.

Thermal Expansion in Hard-Facing

Unequal Cooling Rates, and Lack of Ductility of Alloys Used for Hard Surfacing, Suggest the Need for Preheating to Avoid Failures

By Miles C. Smith*

WITH the growing practice of using high-carbon and alloy steel welding rods there seems to have been a most prevalent disregard of one of the fundamental physical principles entering into such a process. All metals expand or contract in accordance with the raising and lowering of the temperatures to which they are exposed, but hardly any two metals have the same ratio of expansion and contraction. It is not altogether essential that a welder have absolute knowledge of the thermal expansion ratio of every metal or alloy with which he comes in contact, yet it is essential that the welder give some heed to the fact that metals and alloys do expand and contract under the influences of varying temperatures.

Prior to the introduction of high-carbon and alloy steel welding rods when all welding operations on steel were accomplished with a soft steel filler rod or electrode, a welder could pile on the soft steel deposit, even on comparatively cool parent metal, and seldom come to grief. As the soft steel deposit cooled, it quite naturally contracted, but it possessed the property of ductility to such an extent that it actually stretched out as it contracted and neither set up structural strains nor caused disaster. On the other hand, with many of the present-day alloy welding rods, particularly those which have been devised to be used as welded-on overlays, the property of ductility to any perceptible extent is lacking, and such a deposit, contracting as it cools, will set up strains or cause disaster.

Thermal Expansion in Welding Operations

All welders have taken thermal expansion into consideration in the welding of cast iron or aluminum; and all welders realize, through their cast-iron and aluminum welding experience, that unless thermal expansion is heeded and provided for, they cannot hope to be successful in their welding operations. The same thing holds true when welding steel with the present-day alloy rods; and the welder of today, if he wishes to be successful, must take this natural phenomenon into consideration.

Many of the later developed alloy welding rods are designed for use as a welded-on overlay, either to replace metal which has been worn away or to prepare a surface to better withstand wear. They are rarely, if ever, employed except in the formation of a surface deposit. That is, the parent metal is covered with one or more layers of welding beads which are fused with both the parent metal to which they are applied and with each other. Under most conditions, the overlay or deposit consists, after the operation is complete, of a continuous layer of alloy metal with its under side completely fused or amalgamated with the parent metal and its upper side exposed to the air.

In the application of such overlays or deposits, the overlay is formed by melting down, either with the electric welding arc or the oxy-acetylene torch, an alloy welding rod and allowing it to flow over and fuse with the parent metal. Naturally, then, the overlay at the time of application is fully expanded and, as it cools, must contract. If this overlay has been deposited on cold parent metal, it doesn't require any particularly complete metallurgical information to determine what may be expected as the deposit cools. For the most part, these alloy overlays possess little, if any, ductility, so they cannot stretch as they cool and must provide for their contraction by, at the best, setting up structural strains in both the deposit and parent metal or by fracturing either the deposit or parent metal or both.

There can be no denying that welded-on overlays offer to the welder untold opportunities. At a not far distant day, surface preparation against wear and surface preparation to combat many other conditions by the welding on of overlays will be general practice. The development of this process adds greatly to the welders' scope of usefulness in industry, yet it is absolutely essential that the welders prepare themselves against failure and against the possibility of delaying the adoption of welded-on overlays because of their inability to perform the operation successfully. There is no mystery about the application of welded-on overlays, neither is there anything extremely difficult, yet it is absolutely necessary that welders who do overlay give the process the amount of thought and consideration that it deserves.

For some reason the mention of preheating often stimulates antagonism in welding circles. Preheating is considered as an undesirable adjunct to any welding operation, incurring unnecessary expense which should be avoided if at all possible. Contrary to a prevailing opinion among welders, almost any welding operation would be more successful if the metal to be welded were preheated. It is true that, in many instances, preheating may be dispensed with and the weld will be apparently none the worse for the omission, yet had there been preheating the weld would be much better for the added operation.

Relieving Unnatural Strains

By its name, autogenous fusion welding signifies that it is a process for instantaneously fusing two pieces of metal together. In the procedure, at the point of juncture or fusing, the metal is sufficiently hot to fuse or is actually in a molten state. Naturally heat is radiated, both into the air and through the metal being joined, while the procedure is in process; so the metal, to some extent, becomes heated, particularly that adjacent to the point where the weld is being made. However, the structure of the metal is subjected to unnatural strains in such an operation.

To all of us, the natural laws controlling the behavior of metals under various conditions are more or less of a mystery, yet the fact remains that metals do behave in certain specific ways under certain specific conditions; and one undeniable truth is that all metals when heated to a certain temperature (usually that temperature is far below the melting point) are in a structural state free of stresses and strains. At this temperature, the molecules making up the metal appear to be the nearest at ease and the most susceptible to a change in position. As the temperature of the metal drops from this point, the molecules become fixed in place and resist outside influence toward rearrangement.

With this natural phenomenon in mind, then, it is not hard to understand that metals, at the time when they are in this relaxed molecular state, are much more susceptible to such processes as welding than when they are cold and the molecules are more rigid. Particularly is this true in such a process as that of welding on an overlay. To actually cover a cold metal with a molten metallic layer which will fuse with the surface of that cold metal cannot help but invite trouble. Eventually, the molten metal will cool. If, while it is cooling, the metal can stretch, through its inherent ductility, all will be well. If, on the other hand, the molten metal possesses little or no ductility, its contraction upon cooling will cause trouble. The molten mass has taken a firm hold upon the cold parent metal and will not let go, so, as it cools, the deposit tries to further contract the already contracted parent metal and if both the parent metal and the overlay cannot withstand the strains to which they are subjected, one of two things happens: either the parent metal or the overlay fractures.

Suppose, though, the molten mass be deposited upon a metallic

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surface which is, at the time of application, heated to the point where the molecules of the parent metal are at ease. The parent metal is in an expanded state and receives its overlay while in this state. As the overlay cools, the parent metal cools simultaneously and, although the overlay and the parent metal have quite different ratios of thermal expansion, both will contract as they cool and both will have a molecular adjustment during the cooling which will eventually result in an overlayed parent metal under little or no strain.

Preventing Stresses in Dissimilar Metals

One might suppose that it would be necessary, in an effort to secure the ultimate in results, to compute accurately the proper temperature of the parent metal for each type of application and for each alloy overlay, but, again, nature has made another provision: Metallic molecules will make every effort to adjust themselves to the conditions to which they are subjected, and even a wide variance in thermal expansion and contraction ratios is quite apparently taken care of if the two metals are allowed to expand and contract simultaneously. In the case of welded-on overlays, the overlay will cool simultaneously with the parent metal and to all outward appearances accept the thermal expansion ratio of the parent metal. A molten overlay when applied to cold parent metal acts independently of the parent metal, but a molten overlay when applied to heated parent metal, quite evidently brings about a molecular adjustment in both the overlay and the parent metal so that the composite actually cools to a common state that is free from structural strains.

Metallurgically, autogenous fusion welding, and particularly as it applies to the welding on of overlays, is a most complicated process, but it is both a successful and a dependable process. With neither care nor preparation the results obtained are unexpectedly satisfactory, taking everything into consideration, so why not go just a little further and exercise a reasonable amount of care and make a reasonable amount of preparation to insure of the ultimate in results?

One would hardly expect to make a steel casting by pouring a part of it, then, after that part has become actually cold, pour the remainder with a steel of an entirely different character and analysis; yet such a procedure is no more contrary to good practice than the welding on of a deposit of alloy welding rod to cold parent metal. In the welding-on process, only the very surface of the parent metal need be in a molten state, but the entire body, or at least the part of it which will be affected, should be warm—if possible, warmed to a dull red heat.

The Welder's Obligation to His Profession

As welding processes develop and as welding becomes more and more useful to industry in general, it behooves every welder to protect and assist his industry by acquiring more knowledge of welding procedure and by utilizing more care in his operations. One of the greatest handicaps to the general adoption of welding in the past has been the undependability of the human element. Not all welders are good, careful welders. In the more common welding operations, this doubt no longer prevails, but the day has arrived when the welder should be more than an adjunct to crude repairs and the most simple types of fabrication.

The welder of today must be a tradesman who knows and who takes pride in his profession. The facilities for the advancement and perfection of welding as a business have been provided and have kept pace with the advancement of industry as a whole. Whether or not these facilities are utilized to their fullest extent is up to the welders themselves.

Heat and the effect of heat upon various metals is to every welder a very important, if not the most important, consideration. Unless the welder understands, heeds, and prepares for thermal expansion, he cannot help but fail; and one of the best precautions against failure is—when in doubt, *preheat*, regardless. If you do, you will seldom, if ever, get into trouble.

Proposed Specifications for Fusion Welding of Drums or Shells of Power Boilers

IT IS THE policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the Rules and its Codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the Code, to be included later on in the proper place in the Code.

The Boiler Code Committee has received and considered suggestions for Proposed Specifications for Fusion Welding of Drums or Shells of Power Boilers. This movement is a result of the inadequacy of both riveted and forge-welded construction for such drums or shells for boilers to operate at from 900 lb. to 1500 lb., unless the diameters are kept down to impracticable limits. On the other hand, recently, refinements in the application of fusion welding have made practicable the welding of drums and shells of plate thicknesses up to 3 in. or more, and vessels constructed in this manner have been successfully used in large numbers in connection with petroleum-refinery equipment. The proposed specifications which are now under the joint consideration of the American Welding Society and the Boiler Code Committee are submitted below for criticism and comment thereon from any one interested. Discussions of the proposed specifications should be mailed to the Secretary of the Boiler Code Committee, 29 West 39th Street, New York, N. Y., in order that they may be presented to the Committee for consideration.

Proposed Specifications

1. Drums or shells of power boilers may be welded by the fusion welding process when materials suitable for welding are used in accordance with Pars. S-5 to S-17, or S-264 to S-279, of Section II of the Code, and provided the following requirements are fulfilled.

2. *Test Plates for Longitudinal Joints.* Two (2) sets of test plates from steel of the same heat as the drum plates, prepared for welding, shall be attached to the shell being welded as in Fig. 1, one set on each end of one longitudinal seam, so that the edges to be welded in the test plates are a continuation of and duplication of the corresponding edges of the longitudinal seam in the shell. Weld metal shall be deposited in the test plates continuously with the weld metal deposited in the longitudinal joint of the shell.

NOTE: Recommendations have been made that as an alternative, the test specimen be allowed to be cut out of the welded longitudinal joint at any point, and the hole thus made welded up afterward if the tests of the specimen show the vessel to be acceptable.

3. *Test Plates for Circumferential Joints.* When test plates are welded for the longitudinal joints, none need be furnished for circumferential joints in the same vessel. Where a drum has circumferential joints and no longitudinal joint, a set of test plates of the same material as the shell shall be welded in the same way as the circumferential joint.

See also note under Par. 2.

4. *Stress Relieving.* The complete welded structure or such welded parts separately as may be later assembled by means other than welding, shall be heated uniformly to at least 1100 deg. F. The structure shall be brought slowly up to the specified temperature and held at that temperature for a period of at least one hour per inch of thickness, and shall be allowed to cool slowly in a still atmosphere. The test plates shall be subjected to the above stress-relieving operation either attached to or placed within the parent vessel.

5. *Test Specimens.* The inspector shall select one of the two welded test plates, from which the coupons for tension, impact, and bend tests and for macro and micro examinations shall be removed as shown in Fig. 2.

6. *Tension Tests.* The tension specimen shall be transverse to the welded joint, and shall be the full thickness of the welded plate after the outer and inner surfaces of the weld have been

machined to a plane surface flush with the plate. When the capacity of the available testing machine does not permit of testing a specimen of the full thickness of the welded plate, the specimen may be cut with a thin saw into as many portions of the thickness as necessary, each of which shall meet the requirements.

Each tension specimen should fail in the boiler plate, but if failure occurs in the weld metal or along the line of fusion between weld metal and the plate, then the tensile strength shall not be less than the minimum of the specified tensile range of the plate used.

7. *Bend Tests.* The bend-test specimen shall be transverse to the welded joint of the full thickness of the plate and shall be of rectangular cross-section with width 1½ times the thickness of the plate. When the capacity of the available testing machine does not permit of testing a specimen of the full thickness of the welded plate, the specimen may be cut with a thin saw into as many portions of the thickness as necessary, each of which shall meet the requirements. The inside and outside surfaces of the weld shall be machined to a plane surface flush with the plate. The edges of this surface shall be rounded to a radius equal to 10 per cent of the thickness of the plate. The specimen shall then be bent cold under free bending conditions until the least elongation between any two points within and across the weld on the outside fibers of the bend-test specimen is 30 per cent,

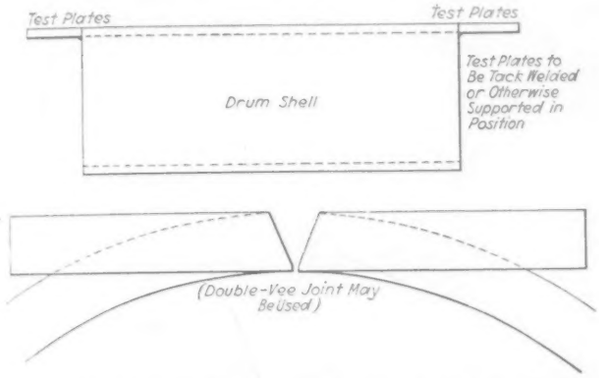

Test Plates
Test Plates
Drum Shell
Test Plates to Be Tack Welded or Otherwise Supported in Position
(Double-Vee Joint May Be Used)

Fig. 1. Sketch Showing Test Plates Attached to Boiler Shell.

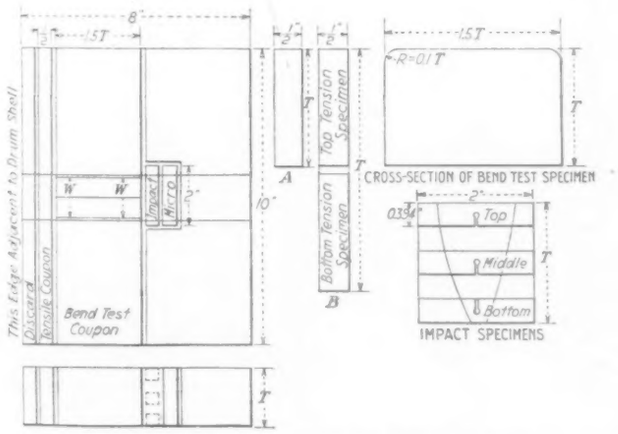


Fig. 2. Test Specimens From Welded Test Plate.

(*A*=cross-section through tension specimen. *B*=cross-section through tension specimen parted in two. *T*=thickness of plate. *W*=gauge length on bend-test specimen.)

with the width of any surface cracks deducted. No surface crack shall be longer than 10 per cent of the specimen's width, when the elongation of the outside fibres has reached 10 per cent.

8. *Impact Tests.* Three coupons for impact tests shall be taken transverse to the welded joint and prepared so that the cross-section of the specimen through which fracture will occur shall contain: (1) the bottom surface, (2) the middle section, and (3) the top surface of the weld. The notch in the bottom specimen shall be opposite the bottom surface, and in the top specimen, opposite the top surface. The minimum value of the impact test shall be 20 ft-lb., standard A.S.S.T. Charpy impact specimen.

9. *Chemical Analyses.* Drillings from the weld metal representing an average sample shall conform to the following requirements:

Manganese	0.30-0.60 per cent
Phosphorus	not over 0.04 per cent
Sulphur	not over 0.045 per cent
Nitrogen as iron nitride	not over 0.020 per cent

The nitride content shall be determined by the modified Allen method of the Bureau of Standards (Scientific Paper No. 457, U. S. Bureau of Standards).

NOTE: A majority of those who have been consulted consider this test unnecessary.

10. *Macro and Micro Examinations.* Macrographs prepared from coupons taken across the welded joints and etched with suitable reagents shall show no laps, excessive porosity, nor incomplete fusion. Micrographs of polished specimens taken in the same manner shall show no evidence of coarse-grained material.

NOTE: A majority of those who have been consulted consider this test unnecessary.

11. *Retests.* Should the bend or impact tests fail to meet the requirements by less than 25 per cent, retests shall be allowed on specimens cut from the second welded test plate. These retests shall comply with the requirements. Should any of the original tests fail to meet the requirements by 25 per cent or more, no retests shall be allowed. If the tension test fails to meet the requirements, additional tension tests shall be allowed on two specimens cut from the second test plate and both of these shall meet the requirement.

12. *Non-Destructive Tests of Vessel.* The welded joints of the annealed structure shall be explored by an approved recording non-destructive test, such as an electrical or magnetic fissure detector or X-ray apparatus, which will determine quantitatively the size of a defect.

NOTE: A majority of those who have been consulted consider this test unnecessary.

13. *Fatigue Tests.* The annealed vessel shall be subjected to 10,000 cycles of pressure, each cycle varying from zero to 1½ times the working pressure. These cycles of pressure should preferably be applied at the rate of 10 to 12 per minute.

The welded joints shall then be again explored by the approved non-destructive test apparatus. The second set of readings shall show that no change in the welded joints has occurred during the fatigue test.

NOTE: Objections have been raised against this test by those who consider it unnecessary or capable of dangerously affecting the structure.

14. *Holes.* No holes shall be located in a welded joint.

When holes in the plate are located near a welded joint, the minimum distance between the edge of a hole and the edge of a joint shall be equal to the thickness of the plate, when the plate thickness is from 1 in. to 2 in. With plates less than 1 in. thick, this minimum distance shall be 1 in. With plates over 2 in. in thickness, the minimum distance shall be 2 in.

15. *Allowable Working Stress.* When constructed under the above provisions, the maximum unit working stress of a welded joint may be taken as one-fifth of 80 per cent (16 per cent) of the minimum of the specified tensile range of the plate used.

NOTE: Criticisms have been received which claim that the maximum unit working stress allowed should be from 90 to 100 per cent of the minimum of the specified tensile range.

ASSOCIATION STARTED AT TEXAS WELDING CONFERENCE

In the March issue of *The Welding Engineer* appeared a brief account of the Fourth Annual Welding Conference which was held at North Texas Agricultural College March 13th and 14th. In this account were included a list of the papers read and the names of the authors of the papers. A later report of the conference indicates that one of the most interesting features of the program was the formation of the Southwestern Welding Association, which is intended to be a working organization for the

purpose of solving the many problems of welding in the southwest; helping the individual welder by establishing a clearing house for information about construction; keeping employers posted on where efficient welders can be found when construction work is ready to start; and lending assistance in connection with any proposed legislation which affects welded construction with which is being prepared by the city, county, or state. It is hoped that this organization can eventually become affiliated with the American Welding Society. The following officers were elected: W. M. Murphy, Magnolia Gas Co., president; W. S. Mosher, Jr., Mosher Machinery Co., first vice-president; C. F. Schram, Riverside Boiler Works, Wichita Falls, second vice-president; and M. C. Stone, North Texas Agricultural College, secretary-treasurer.

ARC WELDING OIL PIPE LINES*

The construction of an oil and gas line by the electric arc follows somewhat the same general practice as used in any other method of construction. Clearing of the right of way, stringing of pipe, and ditching operations are the same for arc-welded construction as for other types.

In lining up the pipe into sections, when the pipe has bell and spigot ends, the spigot ends are inserted in the bell ends of the

Welding a Section of the Line. The Section Is Kept Level by Blocking Up With Wooden Skids.

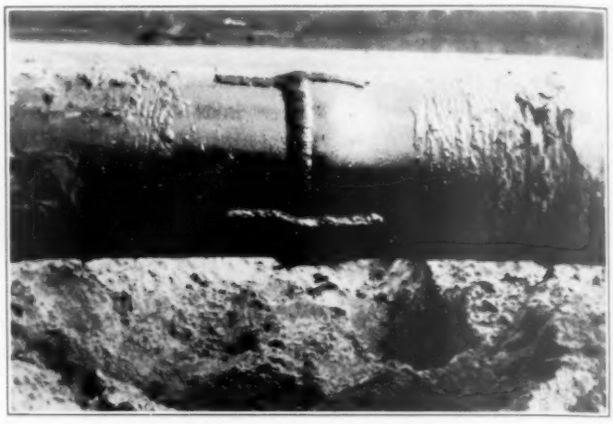
adjacent lengths, thus forming a straight line of pipe. The entire section, thus formed, is blocked up level on wood skids parallel to and about 3 ft. from the line of the trench.

Several devices are employed to aid the turning of sections during the welding operations. Chock blocks are sometimes nailed to the top skids on which the section rests. These chock blocks are beveled on the face adjacent to the pipe, so that the section will turn easily against the chock blocks. The use of chock blocks also eliminates the necessity of long skids, as the pipe is not rolled on the skids, but is turned against the chock blocks. Long skids are heavy and cumbersome to handle. The placing of chock blocks on opposite sides of the pipe on adjacent skids also tends to keep the section in line before welding.

A more recent innovation has been the use of dolleys placed on top of the skids, replacing the chock blocks. These dolleys consist merely of small rollers mounted on a base, on which the pipe revolves.

The actual welding of a section is performed by one operator aided by a helper. Generally the welder is spotted between two adjacent sections. The operator welds the top half of each joint, starting at the joint farthest from the welder, and works toward the next section to be welded. The helper follows, cleaning this first weld, known as the burning-in weld, with hammer, chisel and wire brush, removing all oxides, etc. After the operator finishes the welding of the top half of the last joint in the section, the helper with a chain pipe wrench turns the entire section 180 deg. The operator then proceeds to complete the burning-in bead in each joint; the helper following, cleaning the remainder of the welds, as before.

When the burning-in welds are completed, the operator is back



A Typical Arc-Welded Bell and Spigot Joint in a 12-In. Pipe Line Crossing the Arkansas River. Straps Are Welded Across the Joint as Added Reinforcement.

at the original starting point, having traversed the entire length of the section twice. The operator then starts welding the second bead, or finish bead, welding a complete joint before moving to the next. The helper turns the pipe as the operator welds the finish bead in each joint. In the entire welding operation, the operator traverses the length of each section only three times. The finish bead is not cleaned. This leaves the helper free to turn the section, so that the finish bead in each joint may be completed in one operation. After a section is arc welded, it is placed over the open ditch on single skids and joined to the end of the welded line.

Two separate beads are welded in making a bell hole joint, the same as required in making firing-line connections, the procedure

On Wide River Crossings Pipe Is Welded Into the Line, Joint by Joint, as It Is Laid From Barges. This View Is of the Mississippi River Crossing of the Texas-Empire Line.

only being different. The operator first makes the burning-in bead in the top half of the bell hole joint. After this portion of the joint is welded, the helper cleans the bead while the operator continues to weld the lower half of the joint. The operator then stands by until the cleaning of the entire burning-in bead is finished. He then proceeds to weld the final or finish bead.

On river crossings the pipe is somewhat heavier than that used for land, and as a rule the welds are reinforced by straps. Necessarily on river crossings the usual procedure cannot be followed and in most cases each joint is welded onto the line and then laid into the river from barges. Heavy cast-iron clamps are used to add weight and help anchor the pipe to the bottom of the river.

*Abstracted from a paper read by A. F. Davis, Vice-President, The Lincoln Electric Co., before the American Welding Society, Cleveland Section, January 17, 1930.

Cutting and Welding Jig Parts*

The Making of Welded Jigs and Fixtures Is Simplified by Standardizing Weld Designs and Cutting All Details from Bar Stock and Plate

By J. R. Weaver†

THE application of welding to the building of jigs, fixtures and machine tools was practically forced upon us about a year ago due to the fact that it was necessary to manufacture this particular line of product on very short delivery. Our business increased very rapidly about that time; so in order to obtain all advantages possible in manufacturing, it was necessary to obtain jigs, fixtures, and special machine tools on short notice.

In all cases of new machine tools purchased from machine-tool manufacturers, it was noticed that invariably any delay was due to the time necessary to make the jigs and fixtures.

When the idea was conceived to manufacture jigs and fixtures from structural shapes welded together, we built several of these jigs and put them through a very thorough test to ascertain whether they would be suitable for our work. We naturally tested these jigs for all the inaccuracies that are liable to occur due to warpage, distortion, etc., and then decided upon a definite program of manufacture which has been extremely satisfactory. The thought was advanced that the jigs and fixtures would not maintain their shape after a period of time, but we have used them for about a year with less maintenance than with cast-iron jigs.

In comparing our deliveries of cast jigs with structural jigs, we found that when putting the orders through for cast jigs in the regular way it required about four weeks to obtain our castings. Of course, it was necessary to make patterns, core boxes, etc. The castings had to be cast, cleaned, etc., before being sent to the shop. We find that with the welded structure, we can obtain the most complicated jig in not more than one week's time—the average time is about four days; and you can readily appreciate what a decided advantage this is in the manufacture of any kind of product.

These jigs are made from hot-rolled steel of whatever shapes and sizes are necessary, welded together. Where hardened pieces are required, these are made from tool steel, hardened and attached to the jigs by means of screws, bolts, etc.; or in the case of bushings, pressed in holes provided for them. We experienced some trouble with the feet on these jigs due to the fact that after the jig was annealed, these feet were too soft, so that chips on machine tools would imbed themselves in these feet. In order to overcome this, we made the feet from tool steel and heat treated them before welding to the jig. These feet are then drawn to a scleroscope hardness of 45 to 50, which is sufficient, but they still can be machined. The results have been very satisfactory.

Standardizing Weld Designs and Stock Sizes

Of course it was necessary, when we adopted welded jigs and fixtures, to change our entire method of manufacturing jigs, fixtures, and machine tools. This not only included the actual manufacture of these jigs and fixtures in the shop but also their design. In order to have the proper information on the drawings, it was necessary to train our tool designers in the art of welding to such an extent that they could put the proper information on the sketches sent to the shop. In order to do this, we incorporated in our standard book several sheets of instruction which, in addition to supplying the workmen in the shop with information, also standardized the manufacture of welded jigs and fixtures.

Fig. 1 shows the various sizes of fillet welds and welded constructions used on jigs and fixtures. This is a standard throughout our shop so that the workman is familiar with it and any reference to it is readily understood.

In order to avoid delays due to material being out of stock, we have listed in our standard book a sheet showing the standard stock sizes of steel that are being used for this particular method of manufacture. Fig. 2 shows such a sheet, which gives the sizes of bar and plate stock. When bar stock is not suitable, the part is cut to size from a plate by means of an acetylene torch.

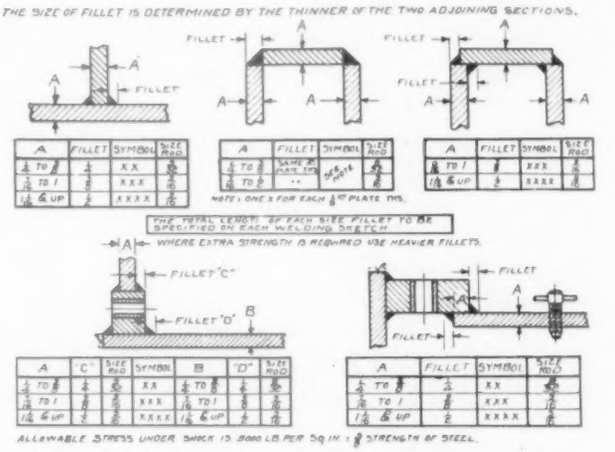

THE SIZE OF FILLET IS DETERMINED BY THE THINNER OF THE TWO ADJOINING SECTIONS.
FILLET
A
NOTE: ONE X FOR EACH 1/8" PLATE THS.
THE TOTAL LENGTH OF EACH SIZE FILLET TO BE SPECIFIED ON EACH WELDING SKETCH.
WHERE EXTRA STRENGTH IS REQUIRED USE HEAVIER FILLETS.
FILLET "C"
FILLET "D"
B
ALLOWABLE STRESS UNDER SHOCK IS 8000 LB. PER SQ. IN. = 1/4 STRENGTH OF STEEL.

Fig. 1. Design of Fillet Welds and Welded Parts.

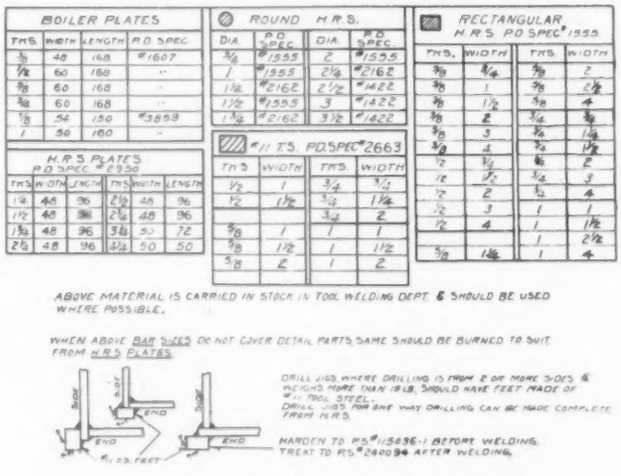

BOILER PLATES
ROUND H.R.S.
RECTANGULAR H.R.S. P.D. SPEC. #1555
#11 T.S. P.D. SPEC. #2663
H.R.S. PLATES P.D. SPEC. #1392
ABOVE MATERIAL IS CARRIED IN STOCK IN TOOL WELDING DEPT. & SHOULD BE USED WHERE POSSIBLE.
WHEN ABOVE BAR SIZES DO NOT COVER DETAIL PARTS, SAME SHOULD BE BURNED TO SUIT FROM H.R.S. PLATES.
DRILL JIGS WHERE DRILLING IS FROM 2 OR MORE SIDES & WEIGHS MORE THAN 10 LB. SHOULD HAVE FEET MADE OF #11 TOOL STEEL.
DRILL JIGS FOR ONE WAY DRILLING CAN BE MADE COMPLETE FROM H.R.S.
HARDEN TO P.S. #15636-1 BEFORE WELDING.
TREAT TO P.S. #2400-34 AFTER WELDING.
#11 TS. FEET

Fig. 2. Material for Use in Welded Jigs and Fixtures.

When the designer makes his drawings of a jig, he lays it out without showing any particular method of construction, and making no reference to welding. Then from this sketch the tool designer makes a second sketch known as a welding and machining sketch; this gives the detail construction and indicates in the bill of material what material is to be ordered, and from the drawing can be obtained information as to the shape desired. This material is then cut from the proper-sized material with a saw in the case of bar stock or with an acetylene torch in the case of a plate.

The title on this sketch indicates the total length of a certain-size weld necessary to completely weld this jig. This is done for the convenience of the time-study supervisor, who estimates

*Paper presented before the American Welding Society, New York Section, January 7, 1930. Abridged.

†Superintendent, Manufacturing Equipment Department, Westinghouse Electric & Manufacturing Co.

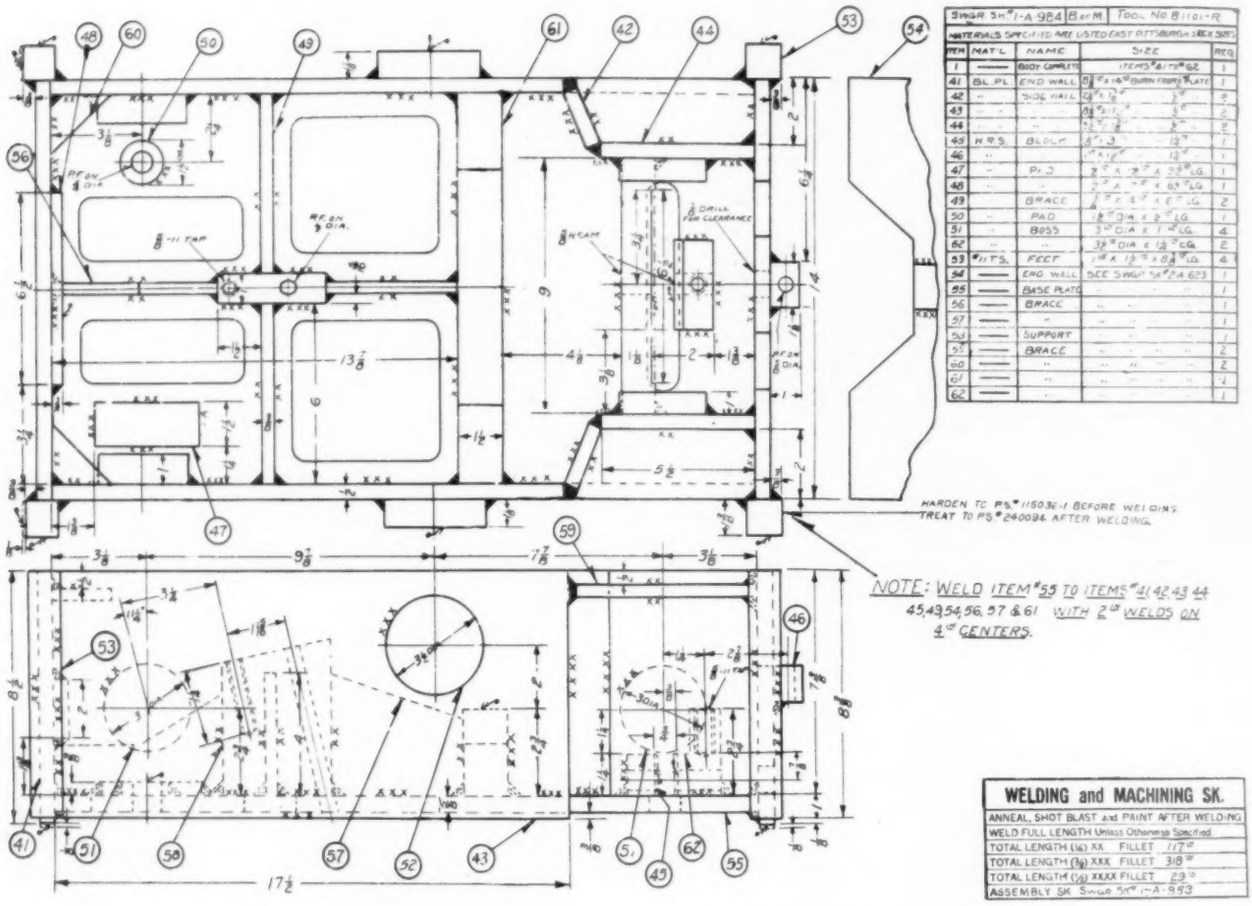

SWGR SK# 1-A 984 B or M Tool No 81101-R
MATERIALS SPECIFIED ARE LISTED EAST PITTSBURGH BILL SIZE
ITEM MAT'L NAME SIZE REQ
1 — BODY COMPLETE ITEMS 41 TO 62 1
41 BL. PL. END WALL 1/2 x 14 x 24 BURN FROM 1/2 PLATE 1
42 .. SIDE WALL 1/2 x 14 x 24 1
43 .. .. 3/4 x 7 x 24 2
44 .. .. 1/2 x 7 x 24 2
45 H.R.S. BLOCK 1/2 x 3 x 13 1
46 .. .. 1/2 x 6 x 13 1
47 .. PAD 3 x 3 x 3 A 3 LG 1
48 .. .. 2 1/2 A 3 x 3 A 3 LG 1
49 BRACE 1/2 x 3 x 6 LG 2
50 PAD 2 DIA x 3/4 LG 1
51 .. BOSS 3 DIA x 1 LG 4
52 .. .. 3 1/2 DIA x 1 1/2 LG 2
53 H.R.S. FEET 1/2 x 1 1/2 x 8 1/2 LG 4
54 — END WALL SEE SWGR SK# 2A 623 1
55 — BASE PLATE .. 1
56 — BRACE .. 1
57 — 1
58 — SUPPORT .. 1
59 — BRACE .. 2
60 — 2
61 — 4
62 — 1
HARDEN TO PS# 115036-1 BEFORE WELDING
TREAT TO PS# 240094 AFTER WELDING
NOTE: WELD ITEM #55 TO ITEMS #41 42 43 44 45 43 54 56 57 & 61 WITH 2" WELDS ON 4" CENTERS.
WELDING and MACHINING SK.
ANNEAL, SHOT BLAST and PAINT AFTER WELDING
WELD FULL LENGTH Unless Otherwise Specified
TOTAL LENGTH (1/16) XX FILLET 1/16
TOTAL LENGTH (3/16) XXX FILLET 3/16
TOTAL LENGTH (1/4) XXXX FILLET 1/4
ASSEMBLY SK SWGR SK# 1-A-983

Fig. 3. Typical Sketch Showing Assembling, Welding, and Machining of Jig Parts.

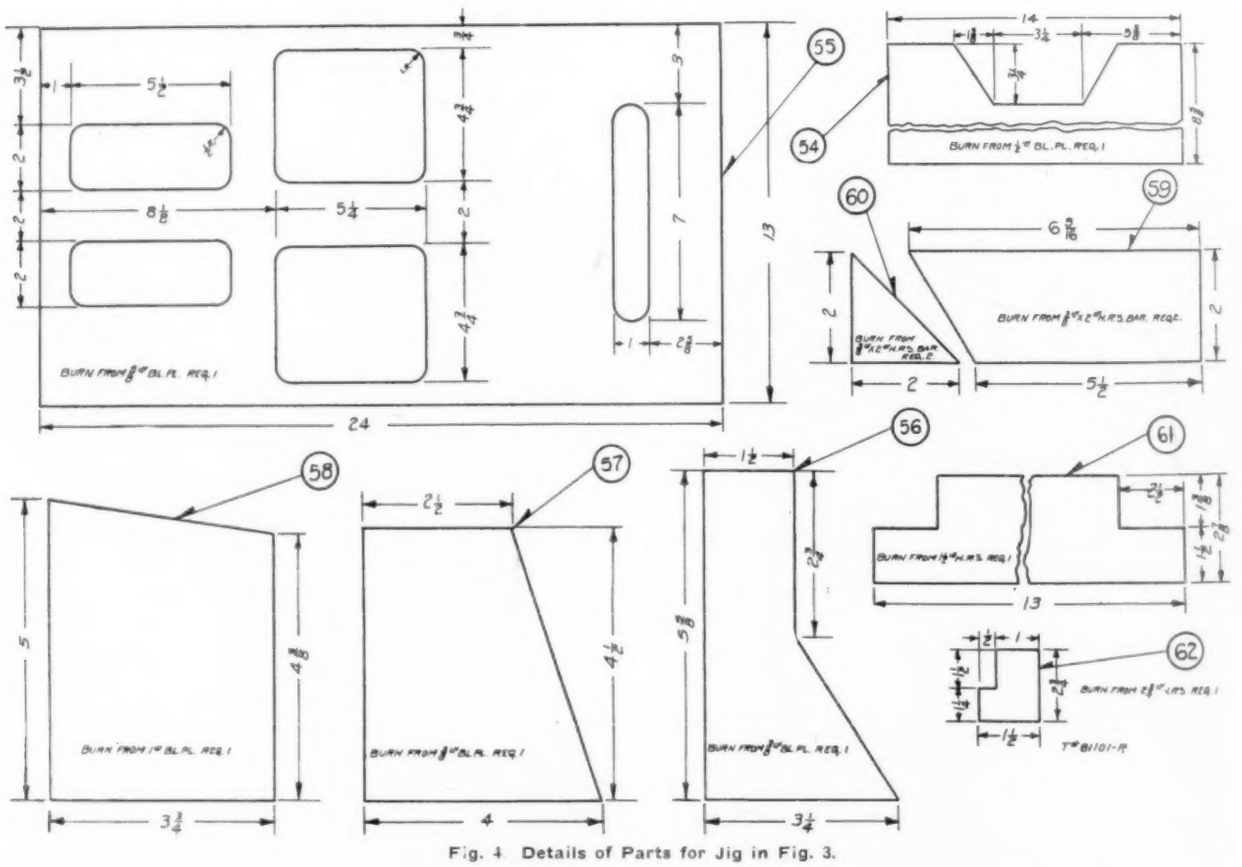

BURN FROM 3/8 BL. PL. REQ. 1
BURN FROM 1/2 BL. PL. REQ. 1
BURN FROM 3/8 x 2 H.R.S. BAR REQ. 2
BURN FROM 1/2 BL. PL. REQ. 1
BURN FROM 1/2 H.R.S. REQ. 1
BURN FROM 2 1/2 L.R.S. REQ. 1
BURN FROM 1/2 BL. PL. REQ. 1
BURN FROM 3/8 BL. PL. REQ. 1
T# 81101-R

Fig. 4. Details of Parts for Jig in Fig. 3.

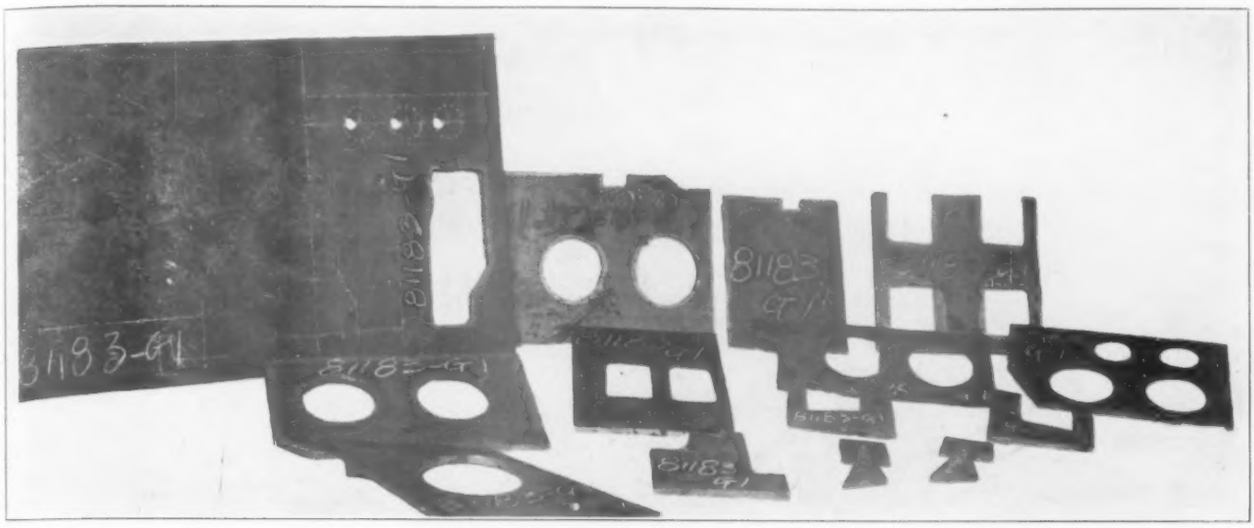


Fig. 5. Various Details Cut with the Torch. Plate at Left Is Marked Off and Holes Drilled for Starting the Cut.

and sets a value on the time it should take to manufacture this jig.

Figs. 3 and 4 show in considerable detail the various parts of a jig and the method of assembling and machining. In Fig 4 the various sections are shown separately so the shop will have no trouble in obtaining the material and cutting it to the proper shape and size.

Fig. 3 also is used for machining purposes, giving the necessary dimensions, etc., that are required to properly machine this jig. In the title on the sketch are given the total lengths of the different sizes of welds necessary to completely weld this jig. This information is an aid to the time-study supervisor in estimating and setting a value on the time it should take to manufacture this jig.

We realize that it is not possible to make a reliable test on a weld without destroying it, and the workman himself must be relied upon for good workmanship. In order to control this phase of the welding process we are requiring that all welders stamp their work with a stencil. This stencil identifies the particular welder who performed the work and, in case there is any question, the work can readily be traced back to the man who did the welding.

Periodically we run a test on welds; and if we discover any welding that is not satisfactory, the workman is required to take additional instruction, or if he proves entirely unsatisfactory he is taken off the job.

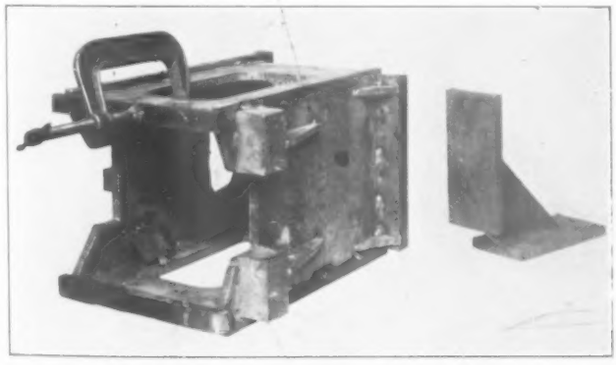


Fig. 6. Tool Steel Foot Being Held on Jig by Clamp for Tack Welding. A Squaring or Setting-Up Angle Is Shown at the Right.

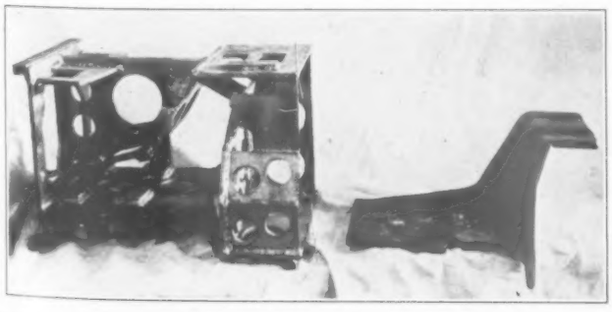


Fig. 7. Body of Drill Jig for Bracket for Talking Movie Machine. (This jig is 15x23 in. and 12½ in. high and weighs only 120 lb. Bracket shown at right.)

Cutting and Assembling Jig Parts

We employ several different types of cutting machines for cutting any shape or size necessary out of plate stock for making jigs.

Fig. 5 shows a number of parts cut to size to make a jig. These various detail parts are assembled and tack welded just sufficiently to hold them together. This is done by a mechanic so that the parts are properly located, also so that the jig is squared up and is a good job when it is finally finished. After the tack welding, the jig is passed to a welder who completes the job by welding the jig as it should be.

Fig. 6 shows a jig tacked together ready for the welder, and Fig. 7 shows a jig completely welded. The latter jig, although fairly large, weighs only 120 lb., and is used for drilling the bracket which is shown at the right of the jig.

These jigs being made from hot-rolled steel, together with the welding, detracts somewhat from the appearance of the completed jig: also, certain strains due to the welding must be removed from the jig so it maintains the correct shape and size. In order to overcome these conditions, we normalize all welded jigs in order to remove strains. This is done by heating the jigs in a furnace to a temperature of 1000 deg. F., after which they are allowed to cool in the air. Due to the use of hot-rolled steel and the normalizing, a certain amount of scale is present on these jigs and this must be removed. This is done with a sand-blast machine, by which the appearance of the jig is greatly improved. After the sand blasting operation, the jig is spray painted to make the surfaces smooth and prevent chips from adhering to the jig. The jig is then sent to the shop for regular machining, which is no different from what it would be for a cast jig except that there isn't as much material allowed for finish as is ordinarily allowed on castings.

An idea of the extent we have gone in the welding of jigs and fixtures is given by Fig. 8, which shows a jig weighing 1,300 lb., the overall dimensions being 39½x51½x21 in. This complicated jig, to make it as a casting, requires considerable time both in the pattern shop and in the foundry. This jig shown is built entirely of steel, using hot-rolled bar stock and plates. The bosses are made from hot-rolled round steel cut off with a saw and welded in place.

Fig. 9 shows a welded jig being used on a drill press. We

have experienced no difficulty with inaccuracies in these jigs, although we have been using them for approximately a year.

Fig. 10 shows two other types of jigs that we have manufactured. In fact, it is feasible to make any kind of necessary jig by this method.

In addition to the advantages already named, a jig made from steel has considerably more strength and less weight. This is because the jig can be made from thinner material and it is not necessary to increase the sections to reduce casting difficulties, etc. It is also possible to place metal where it is most desired in order to make a stronger jig with the least amount of weight. Also

Fig. 8. Drill Jig for Main Base of Oil Circuit - Breaker. Rear View of Jig Shown at Right.

in case there should happen to be a change in the jig required due to the product being changed or for any other reason, it is very easy to remove any interference by means of an acetylene torch and reweld the parts in new locations if desired.

We found it necessary to design a double-head oxygen-acetylene cutting machine that will cut either straight or bevel edges of various thicknesses of steel. This machine was so constructed that one man could operate both heads, as the controls are so arranged as to be convenient from one position. This particular structure for this machine worked out very satisfactorily and we had no trouble due to misalignment, vibration, or any of the other things that result from faulty design or construction.

Fabricating Special Machines by Welding

Another application of this method of fabrication is the design of special machine tools from the same construction. We have aplied this method of construction only to special machine tools such as we design and build ourselves, but I believe it will be applied to all types of machines in the future.

For example, we have built a machine for testing mica sheets that is entirely welded, with the exception of the worm-gear reduction unit. We are also using winding machines for winding mush-type coils for a-c. motors; these machines are entirely fab-

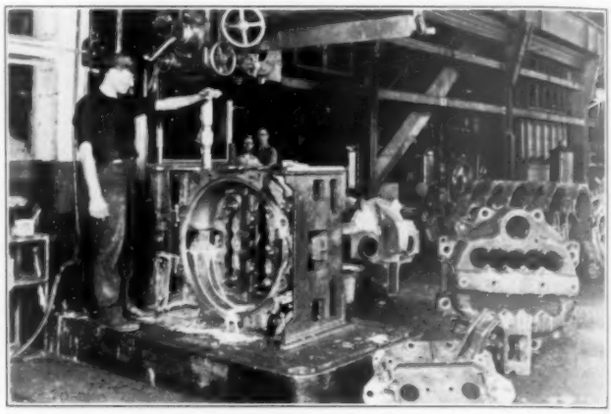


Fig. 9. Drilling Oil-Circuit-Breaker Bases With Jig Shown in Fig. 8.

ricated from structural steel by welding; the welded tail stocks function satisfactorily and, although the requirements are not as rigid as on metal-cutting machines, I see no reason why this construction could not be adopted for other machines with satisfaction.

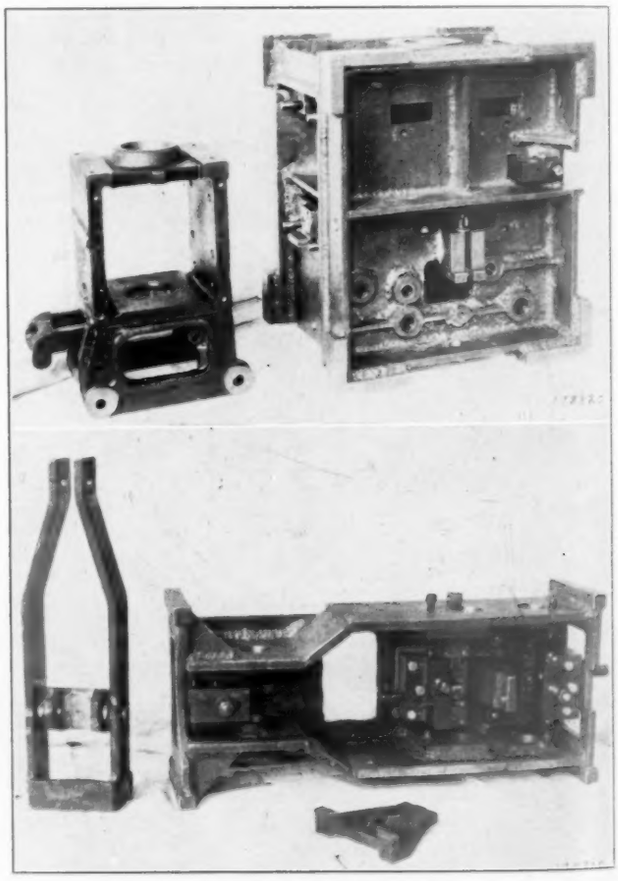


Fig. 10. Examples of Welded Drill Jigs.
(The upper jig is for drilling the solenoid mechanism frame shown on the left, and the lower jig is for drilling the lever shown at the left end of the jig.)

I realize that some further development is necessary before this particular type of construction can be applied to general machine tool construction. I am calling these particular facts to

your attention because I believe these are successfully demonstrated in our shop and that they show the practicability of welded jigs, fixtures, and machine tools, and structural steel welded together, which obtains a decided advantage from several angles.

I am building from 200 to 400 welded jigs and from three to six special machines per month. By the method described, I have been able to build these tools in shorter time, reduce the average cost approximately 25 per cent, and produce a jig or fixture that I believe is more desirable due to the fact that it is lighter and, at the same time, of at least equal strength. The jigs and fixtures which have been built in this way have required less maintenance. I do not think we have sacrificed anything due to misalignment, warpage, distortion, vibration, etc., nor taken anything from the appearance of this particular type of equipment.

WELDING ALL-STEEL STRUCTURES

THE arc welding of trusses, observation towers, and other all-steel structures presents no new problems in welding technique; and the opportunities in this field can well be taken advantage of by the small shop that is successfully handling odd welding jobs. One of the smaller shops that have expanded their business through arc welding is the Joliet Engineering Co., of Joliet, Ill., who are keeping two motor-generator sets and one transformer set busy in the welding of structural steel.

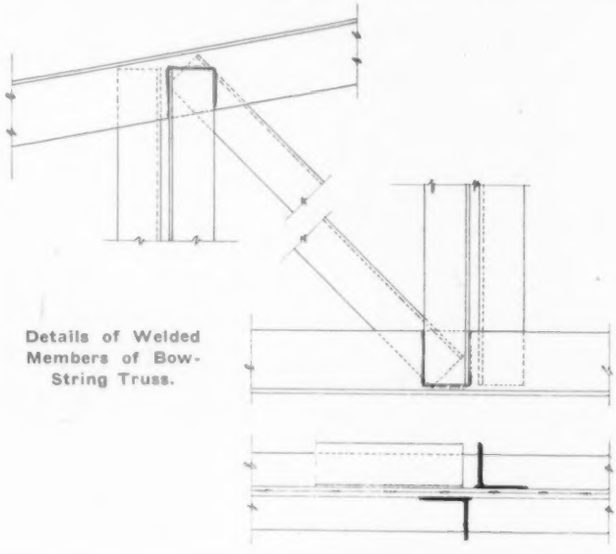
This shop, said J. J. Wallace in an address given before the November meeting of the American Welding Society, Chicago Section, started in first of all to weld up lintels for residence and industrial buildings. On one job a change was made where two angles had been welded together using pipe separators as the interlocking medium. The contractor on the job had a husky laborer pounding for an hour with a heavy maul, and finally had to have some cutting equipment sent on the job to remove the separators. This experience increased considerably the confidence of this contractor in arc welding, and before long he was specifying that steel work on his jobs be arc welded so the rivet heads would not be in the way of construction.

Trusses with spans varying from 18 ft. up to 96 ft. have been fabricated in this shop by arc welding. The largest of such units was a bow-string truss composed of two 6x4x⅜-in. angles in the top chord and two 5x3x⅜-in. angles in the bottom chord. The vertical compression members were made of two 3½x3½x¼-in. angles set in star fashion, and the tension members were composed of one angle of the same size.

An analysis of the stresses in this truss discloses that some of the shorter compression members are not stressed as high as they could be, and also that there is some extra material in some of the tension members. However, the unwieldliness of the finished truss and the erection stresses encountered prompted the use of a little more steel in some spots than might appear necessary. It is an interesting fact, however, that no gusset plates were used except at the center connection (the truss being built in two units), at the end bearings, and at the quarter point on the top chord. The two halves of the truss were shipped separately, and were bolted together upon erection. This truss is set on steel columns, and the column caps and bases are also welded.

When the bids were being taken on this job, the span and the panel distance were given. Several different types of riveted trusses were considered, as well as different types of welded trusses. In general the welded trusses were 25% under the riveted trusses in price. This saving is made up of several different items. In the first place, a welded truss takes less material than a riveted truss; also, the drawings are simpler; the laying out and the template work are reduced to the minimum; and welding certainly involves considerably less labor than punching and riveting. The total saving is a large factor in the final cost.

An all-welded observation tower is another product of this



Details of Welded Members of Bow-String Truss.

Bow-String Welded Truss of 96-Ft. Span.

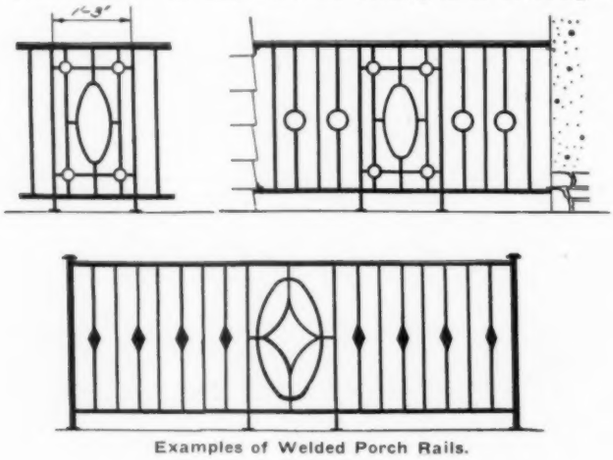
small shop. The owners of this tower became so enthused over arc welding that it was at their insistence that the erection bolts were removed, so no bolts or rivets were left in the structure, except the foundation bolts. This tower is 24 ft. square at the base and 20 ft. square at the top platform, and the observation floor is 30 ft. above the ground. The rails, steps, in fact everything, is steel.

Among the jobs handled by this shop has been the welding of connections to beams and columns, some of the latter being 40 to 50 ft. high. Girders of 40 to 50 ft. span have been welded, as well as many machine bases.

All-Welded Observation Tower.

In addition to such welded structures as those already mentioned, many riveted jobs are being turned out. One job of approximately 200 tons is a combination of riveting and welding. Those in charge of this shop have no preconceived notions concerning the relative advantages of welding and riveting on any particular job; if riveting is wanted, that is what the buyer gets. Every opportunity is taken, however, to acquaint their customers with the advantages of welded construction for many kinds of steel structures.

The owners of his shop also find welding to be advantageous

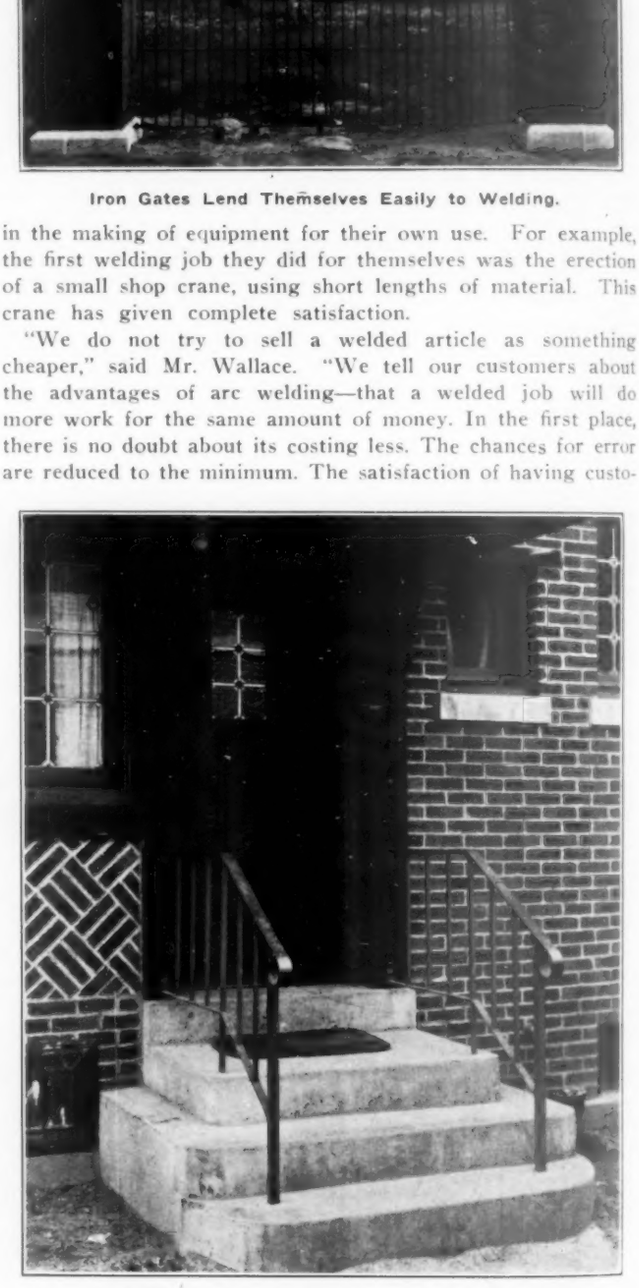


Examples of Welded Porch Rails.

Iron Gates Lend Themselves Easily to Welding.

in the making of equipment for their own use. For example, the first welding job they did for themselves was the erection of a small shop crane, using short lengths of material. This crane has given complete satisfaction.

"We do not try to sell a welded article as something cheaper," said Mr. Wallace. "We tell our customers about the advantages of arc welding—that a welded job will do more work for the same amount of money. In the first place, there is no doubt about its costing less. The chances for error are reduced to the minimum. The satisfaction of having custo-



The Welded Job Can Be Artistic, as These Rails Show.

mers pleased by the absence of rivet heads is important. Moreover, a shop can turn out more tonnage in the same time, which naturally reduces the overhead. Electric welding has been in existence since the 'eighties. Its ability to hold is unquestioned, and I highly recommend it to anyone considering structural-steel fabrication."

The experiences of this Joliet shop brings to mind many other possible applications of welding in construction work, such as fire-escapes, tank supports, skylights, electric signs, and many others. Here is a vast field that awaits to be conquered by the welding shop, large or small.

Welding of Copper Vessels and Pipe*

Careful Consideration of Physical Properties, Proper Design, and Correct Welding Technique Will Produce Satisfactory Results

By Stephen Mashl†

BEFORE discussing the possibilities of copper welding, let us first mention a few things about copper, its physical properties, its action under the acetylene flame. By noting the action of the metal, we are able to foretell with some measure of accuracy the results that will be obtained when the welding of this metal is actually started.

There are several grades of copper, the purest of which is electrolytic copper and is not suitable for welding. The next grade is known as best selected copper, and is used in making bronzes and alloys. The third grade is called tough pitch copper, and is the copper that is generally used.

Copper has very high heat conductivity, and for this reason a larger torch tip must be used than for steel. It also has a higher coefficient of expansion than steel; therefore different methods must be used for taking care of expansion and contraction. Copper is a very soft ductile metal and can be cold-worked a good deal, but it has the property of becoming hard and brittle when cold-worked. It is very easily annealed by heating to about 700 deg. F. and cooling in air or water, as conditions permit.

The tensile strength of cast copper is from 19,000 to 26,000 lb. per sq. in. For pure wrought copper, it is about 36,000, and for wire it ranges from 38,000 to 60,000. Copper loses its strength rapidly with an increase in temperature, and at 700 deg. F. the tensile strength is about one-half that at room temperature. The melting point is 2,000 deg. F.

Solving the Oxide Problem

As copper melts, it has a great affinity for oxygen and this forms layers of copper oxide within the metal itself. This is very detrimental, so some means of preventing this oxidation must be used. There are various substances used as deoxidizing agents, the most important being phosphorous, boron-suboxide, aluminum, and silicon.

The rod used is of great importance. It must contain some substance that will dissolve the oxide and bring it to the surface of the weld or else work to prevent the formation of the oxide. The rod should have the same melting point as the article to be welded. It should be of uniform composition. Then the finished weld, if properly executed, will be strong, tight and ductile.

When beginning the weld, it is very necessary to have the copper at the melting point before applying the rod. If the rod is added before this temperature has been reached, the rod will only adhere to the surface and we will not have a good weld. Many welders make a finished weld that looks good, but lacks strength. Some welders burn the metal by keeping the torch too close to the work and by keeping the same spot molten too long. The best results are obtained when the rod is applied at the same time that the parent metal becomes molten. The two metals then unite to form a perfect weld. In remelting the weld it is very important to always add filler rod to prevent excessive oxidation of the copper.

Annealing the weld after it has cooled has a very beneficial effect on the structure of the weld and increases its strength.

Welding Procedure in the Plant

In all cases, we try to make plain butt welds, as these are so much easier to make and are as near to being the perfect joint as it is possible to make.

When welding tubing, we always butt the tubes together and tack them in three or more places and then proceed with the welding. The method used is about the same as for steel with a few exception, which are as follows: The part to be welded must first be heated for a few inches to heat up the metal next to the weld, the reason for this being that were this precaution not followed, the first portion of the weld would crack due to too rapid cooling of the adjacent metal. This can be readily understood when we stop to consider the heat conductivity of copper. After the parts to be welded are heated, the actual welding is started and is carried on as rapidly as is consistent with good work. The metal is brought up to the point of fusion and at the same time that the metal begins to melt, the rod is inserted into the weld and then carried forward with the weld, with as little puddling as possible. It is easy to obtain a strong weld, but it takes close observation while welding in this manner if one is to have a weld and not merely add the rod without fusing it properly to the parts being welded.

In welding heavy copper sheets it is not possible to weld in this manner. Then one must move the rod as in the welding of steel, always making sure that the part being welded is in a state where it is just about molten; and then and not before, the rod is to be added to the weld. The metal should never be kept in the molten state without adding filler rod to the puddle to prevent excessive oxidation of the metal and consequently a poor weld.

Welding Long Seams

In welding long seams we have found it best to start at one end and weld in one direction only. We have tried several methods of controlling the expansion in seams from 4 to 8 ft. long and have had good results with the following two:

In the first one we had to weld up a seam in 8-gauge sheet. The seam was 8 ft. 4 in. long. On this we tried bolting two steel angles on each side of the sheet and about 4 in. from the edge to be welded. This was done on both sheets so that it was possible to hold the sheets in any position by means of clamps or wedges. The angles prevented the sheet from warping and also acted as chill plates. This method was good, but took more time than the following, which we now use in preference to any other:

To weld a long seam we place the two edges to be welded together on a straight 4-in. H-beam. Then the edges are hammered down until they lie flat on the beam. We then tack the sheets at one end and put a clamp on the other end to hold the sheets a short distance apart. The welding is then started, and as it proceeds the clamp is loosened from time to time to allow the sheets to draw together. Sometimes it is necessary to speed up the rate at which the welding is carried on, in order to prevent the sheets from overlapping each other. At other times it is necessary to slow it down in order to prevent the space between the sheets from becoming too wide. When the sheet warps, it is an easy matter to hammer the edges down without interfering too much with the welder. We have approximately eighty seams ranging from 5 to 10 ft. in length in copper sheets that range in thickness from 16 to 8 gauge, and up to date we have not experienced any trouble with them. The few leaks that did develop were always small pin holes, and no trouble was experienced in repairing them.

*Paper read at the meeting of the Chicago Section, American Welding Society, March 6, 1930.

†Van Schaack Bros. Chemical Works, Inc., Chicago, Ill.

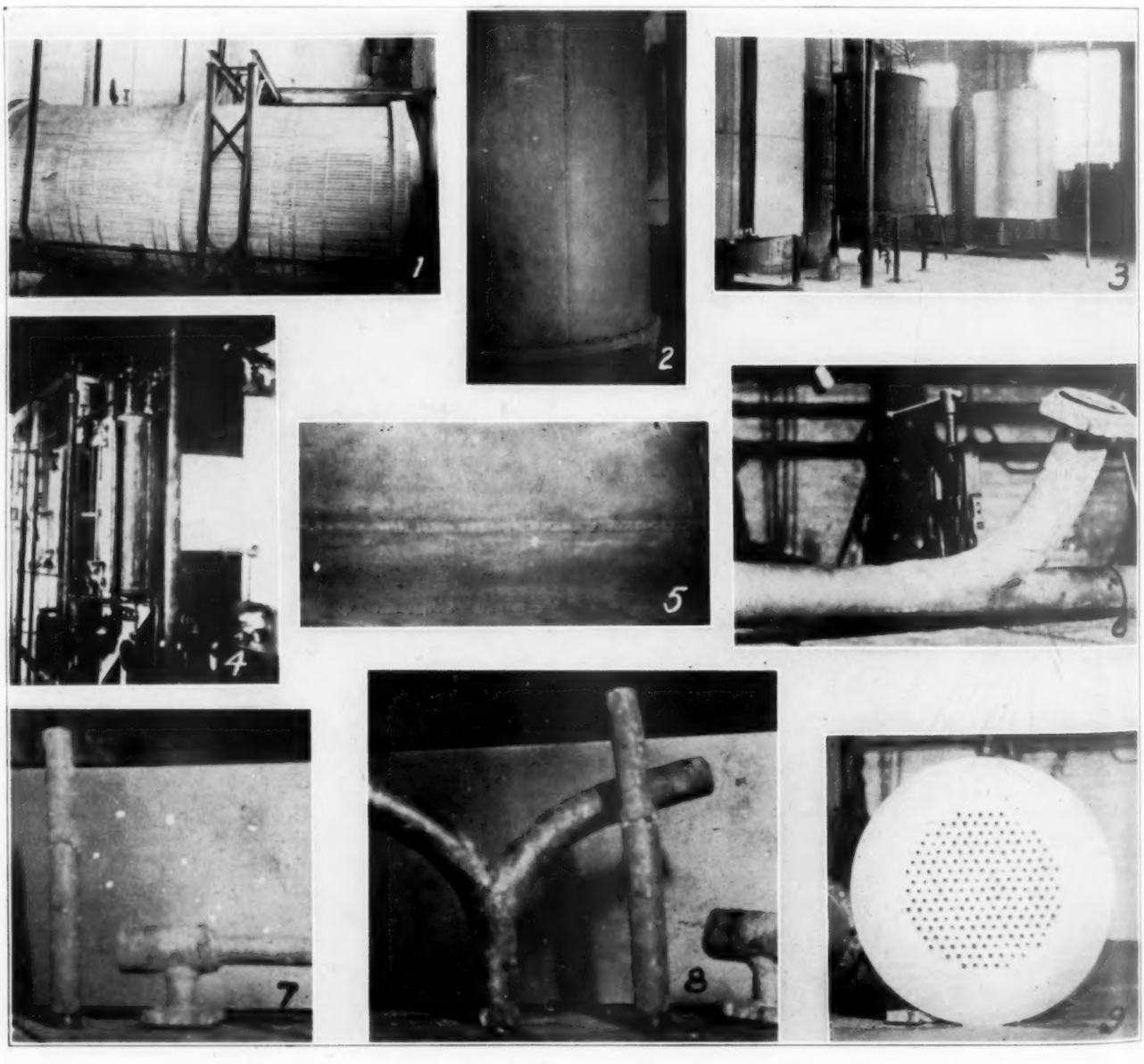
Design and Procedure for Tank Welding

In welding tanks, we have found it best to use the butt weld wherever possible, as it is the strongest and easiest to make. First the longitudinal seams are welded and then the heads are welded to the shells. When it is necessary to make the head of two or more pieces, these pieces first are welded together and then the head is flanged over from ¾ to 1½ in., depending upon the size of the tank and the thickness of the copper sheet. Flanging the head makes it easy to tack to the shell; and this type of construction does away with the welds cracking, as it is very poor practice to make a corner weld in any vessel that is subjected to any pressures or loads such as might be created by the weight of the tank itself or the expansion and contraction of pipe that is connected to the tank.

The illustrations shows various articles that have been fabricated in the plant shop. Several of these are of tanks of various sizes used for different purposes. The one shown in Fig. 1 is still used in the manufacture of ethyl acetate. It is made of four sheets of 8-gauge copper, with two longitudinal seams welded both inside and out. The heads are flanged and sweated to the shell as in the middle girth seam. This still is about 14 ft. long and has a capacity of 5,000 gal. The working pressure is very low, not exceeding 5 lb. per sq. in. When the still was completed, it was tested hydrostatically to a pressure of about 25 lb. per sq. in. There were very few leaks, and these were repaired by peening and soldering, and to date there are no indications of any leaks.

The tank in Fig. 2 is used as a receiver on a still. It has a capacity of 490 gal. and the seams are copper welded. The heads are flanged and sweated on, the reason for this being that the shell of the tank corrodes much faster than the bottom, so when rebuilding the tank we use the same bottom and put on a new shell. There is no pressure on these tanks except the pressure created by the contents. Previous to copper welding these tanks, brazing was used with a hammered lap weld, which always failed in the brazing, the contents of the tank being of such a nature as to eat away the zinc and leave a very porous joint which gave a good deal of trouble. We have practically no trouble with

Fig. 1. 5,000-Gal. All-Welded Still Made of 8-Gauge Copper With Two Longitudinal Seams Welded Inside and Out.
Fig. 2. Welded Seam in 490-Gal. Receiver.
Fig. 3. Receiving Tank of 12-Gauge Commercial Copper, With Longitudinal Seam Butt Welded.
Fig. 4. 24x8-In. Tanks of 16-Gauge Copper Tested to 100 Lb. Pressure and Used in Experimental Laboratory.
Fig. 5. Close-Up View of Oxy-Acetylene Welded Seam in 12-Gauge Copper Tank.
Fig. 6. Acid-Metal Flange Welded to 3-In. Extra-Heavy Copper Pipe (I. P. S.) With Copper Rod.
Fig. 7. Heat Interchanger With End Copper Welded.
Fig. 8. This Tee Is Made of 16-Gauge Copper Tubing, 2 In. Outside Diameter, Welded to Copper Pipe (I. P. S.).
Fig. 9. End View of Condenser Made Up of 199 8-Ft. ½-In. Outside Diameter, 16-Gauge Copper Tubes Brazed Into a ½-In. Thick Cold-Rolled Copper Head. Vessel Tested to 100-Lb. Pressure.



the copper welded seams. They last as long as the shell of the tank itself.

Fig. 6 is a part of a heating coil used in the smaller stills. It has an acid-metal flange welded to extra-heavy copper pipe with copper rod. The results are very good, as the coils stay tight until the pipe is so thin as to render it unfit for further use. Before copper was used on this joint, the flanges were brazed on, but they had to be rebrazed about every eight or nine months. So the saving made is really worth while.

Figs. 6, 7 and 8 show some copper welded fittings that are used in different parts of the plant, the sizes ranging from 1 to 5 in. outside diameter, and the working pressures from 0 to 150 lb. gauge steam pressure. The only leaks are occasional pin holes. The welds have never ruptured, which indicates that they are amply strong for the service imposed on them.

Fig. 9 shows a standard condenser. This condenser has heads of copper plate ½ in. thick and the tubes are of 16-gauge seamless tubing, ½ in. outside diameter and 8 ft. long. There are 199 tubes in the head on ¾-in. centers; these tubes are brazed into the heads with No. 21 H. S. brass rod.

Successful Brazing of Condenser Head

This presented a problem in brazing, as the difference in thickness of the heads and the tubes is so great that it is almost impossible to heat the head to a red heat without burning the tubes off. The spacing of the tubes also renders it difficult to get the spelter down on the head without burning the tubes. We solved

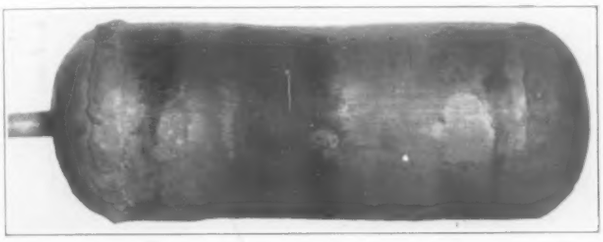


Fig. 10. Copper Test Cylinder With Welded Heads, Which Was Subjected to 1,000 Lb. Hydraulic Pressure Without Failure.

the problem by using a charcoal preheating fire and allowing sufficient time for the tubes and head to come up to a good heat, taking care not to heat the condenser red hot. To make the fire hot enough we had to use an air blast from a coil with a number of holes in it which was placed under the fire. This arrangement gave us as much heat as was required and allowed good control of the heat also. Forty pounds of charcoal was used in heating the large head and about 30 lb. was used in heating the small head.

The welding procedure was as follows: The head and tubes were assembled and the condenser was placed in an upright position. Then the preheating fire was started. About 1½ hr. was required to bring the head to the right heat. The next step was to sprinkle some flux over the parts to be brazed. Then we started the actual brazing, using a torch with a No. 12 tip for melting the rod and a second torch with a No. 15 tip for preheating the work. This method enabled us to keep the parts to be brazed at a red heat directly in front of the torch doing the brazing. To prevent burning of the tubes, it was necessary to keep the torches moving at all times and to hold them about an inch away from the work.

In order to keep the brass from running off the work, we undercut the head, which also made it easier to heat. By doing this we had ¼ in. to fill up with brass, which was more than enough for the purpose. When care is used in handling the torches, no difficulty is encountered in making a tight job. When finished, the condensers are tested with air at 75 to 80 lb. pressure. There are 14 of these condensers now in actual use and no trouble has developed, although some have been in service nearly two years.

When these condensers were first made, the heads were tinned and the tubes were also tinned into the heads, but the results were very unsatisfactory and the condensers had to be changed about every three weeks, to say nothing of the material that was spoiled and which had to be redisstilled. Taking everything into consideration, tinning was an expensive proposition. Up to date, we have not found it necessary to change one of the brazed condensers, which is good proof of the success of the brazed head.

The actual time required to braze one head is about 20 minutes for two welders and one helper. Tinning took one man about 3 hr., not including the time required to tin the tubes and the head before assembly, but this work was offset by the machining done on the heads when preparing them for brazing. The labor cost for both types of construction is about the same, but the results are vastly different and in favor of the brazed construction. Tin did not have strength enough to hold the tubes when they were subjected to the expansion and contraction strains set up while the condenser was in operation.

A. W. S. ANNUAL MEETING

The welding of steel structures and of boiler drums will be featured at the Annual Meeting of the American Welding Society to be held April 23rd to 25th at the Society's headquarters, 33 West 39th St., New York City. Five technical sessions and eleven technical papers are announced in the program just released by the Society. In addition, there will be important committee meetings and social events.

An important feature of the meeting will be a symposium devoted to the welding of power-boiler drums and shells. A tentative code for such welding has already been issued for criticism by the Boiler Code Committee of the American Society of Mechanical Engineers. It is expected that the discussion at the symposium will center around this Code. F. R. Low, editor-emeritus of *Power* and chairman of the above committee, will preside at this session.

In the number of papers presented, structural steel welding dominates the meeting program, with many items of interest to architects and engineers. Perhaps the most significant of the structural sessions will be the meeting of the Structural Steel Welding Committee, to be presided over by J. H. Edwards, chief engineer, American Bridge Co.

At the first technical session, which will be held in the forenoon of April 23rd, there is scheduled a paper by L. C. Bibber of the Bureau of Construction and Repair, Navy Department, on "Distribution of Stresses in Fillet Welds." At the same session, C. D. Jensen of Lehigh University has a paper on "Investigation of Beams Welded to Columns." Tentative plans have been made for an inspection trip in the afternoon.

For Thursday morning an Architectural Session is being arranged covering the subject of welding from the view-point of the architect and builder. It is expected to have three important papers. The papers scheduled for Thursday afternoon are: "Construction Panel Heating by Welding at the British Embassy," by a representative from Wolff & Munier, Inc.; "Battledeck Welded Floor Construction," by Lee H. Miller, American Institute of Steel Construction, Inc.; and "Stiffness of Welded Beam Connections," by C. H. Jennings, Westinghouse Electric & Manufacturing Co.

Thursday evening is reserved for the Annual Dinner. These dinners have been getting better every year, which is something of an accomplishment for the Dinner Committee. Everyone who is fortunate enough to be able to come to the Annual Meeting should certainly make his plans to be on hand at the Dinner Thursday evening, for there will be plenty of sociability and entertainment.

Another technical session will be held Friday morning, at which the following papers will be presented: "An All-Welded Barge," by E. W. Ewertz, Consulting Engineer; "The Needs of the Metropolitan District for Instruction in Welding," by R. F. McKay, International Oxygen Co.; and "Welding of Tube-Turns," by Nate Lord, Tube-Turns, Inc.

Friday afternoon is reserved for meetings of the Structural Steel Welding Committee and the American Bureau of Welding.

Hints for the Welder

WHEN YOU FIND a new way to do a hard job, or finish a particularly interesting weld, can you describe how the work was done? . . . . . Have you learned some little stunt every welder ought to know? . . . . . Write to us about these things . . . . . This department helps you welders to help each other. Write up your ideas any old way and just make rough pencil sketches . . . . We'll fix them up for publication.

DEPOSITING GRAY CAST IRON WITH THE METALLIC ARC

By Thomas D. Ketchbaw,
Metallurgical Engineer, Kayness Corporation

The accompanying photographs show a very interesting repair job which was made at the plant of the Chicago Cutting Die Co., using Scolite electrodes for depositing gray iron. The casting is the main frame of a large "bull-dozer" weighing over 4,000 lb. Due to the nature of the work done with this type of machine, the casting is subjected to enormous stress at the points of fracture.

There are several peculiarities of cast iron which must be kept constantly in mind when attempting to weld this metal with the metallic arc, making a gray-iron deposit in the weld.

First, it must be remembered that since cast iron is so brittle that it will not elongate (stretch), it is necessary to consider the expansion and contraction effects. If the part to be welded is of a nature which would be affected by a localized heat, the part must be preheated sufficiently to eliminate any danger of fracture or distortion.

Second, to avoid the changing of the carbon from the free state to the combined state, there must be a sufficient amount of heat in the casting to eliminate this "chilling" effect. In either case, 700 to 900 deg. is ample to serve the purpose. In

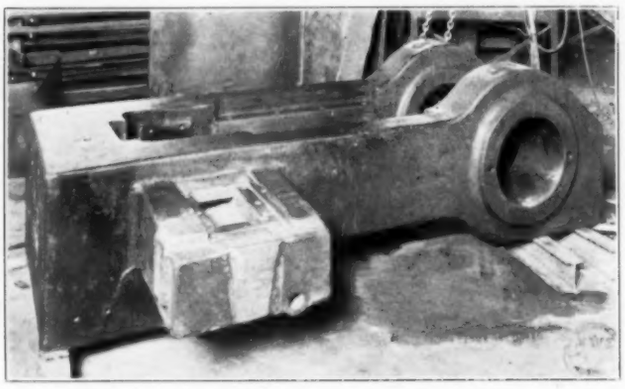


Fig. 1. Casting Veed Out at Each of Three Fractured Places Preparatory to Welding.

the welding of small sections, where the applied heat of the arc will be sustained long enough to thoroughly heat the casting adjacent to the weld, there will be no possibility of hard spots.

The amperage used in applying Scolite, which is a cast-iron electrode made by the Kayness Corporation, is rather high compared to the amperage used in other arc welding practices. For welding with $\frac{3}{16}$-in. electrodes, 200 to 250 amp. is the range; for ¼-in. electrodes, from 250 to 350 amp. Even a higher amperage may be used without danger of damage in any way to the weld metal; and the arc, even at this high heat, is stable enough to allow the molten metal to flow from the electrode with very few sparks. It is possible to deposit as much as 15 to 18 lb. of weld metal per hour, using ¼-in. to $\frac{5}{16}$-in. electrodes at 250 to 350 amp.

Reversed polarity is used with this material. If the electrode is on the negative lead, very poor results may be expected as there will be very little or no penetration. With reversed polarity—that is, the electrode on the positive lead—a penetration of ¼ in. is not unusual.

In the welding of thin sections, care must be exercised to prevent melting entirely through the part being welded. It is sometimes necessary to place a piece of carbon plate under such sections to facilitate the progress of welding. In such cases, the amperage should be decreased and a smaller electrode used.

Fig. 1 shows clearly the points of fracture and the method of preparing the parts for welding. As the casting was of a

Fig. 2. After Preheating in a Temporary Furnace, the Part is Welded.

very heavy section, a series of holes were drilled through the casting, forming the customary V-shaped opening at each fracture to permit welding entirely through the member. A small firebrick preheating furnace was constructed to enclose the parts of the casting adjacent to the fractures, the remainder of the casting being outside the furnace. Charcoal was used in heating the casting, and at no time was the casting at any point—outside of the actual weld—heated in excess of 900 deg. F. Flat carbon plates of suitable size were used as a base upon which the bottom of the weld was formed. This was necessary, due to the extreme fluidity of the cast iron under the arc.

Owing to the fact that the casting was porous and a great amount of sand was included at different points, extreme care was necessary to float out all the slag which formed and tended to cling to the side of the V-shaped opening. This slag, which is very near the specific gravity of cast iron, will form pockets and consequently result in an inferior quality weld, hence great care must be exercised in puddling the pool of molten metal. The puddling is accomplished by manipulating the arc in an oscillating or even a rotary motion, which causes all slag or impurities to float to the surface, where they can be scraped off.

The following are facts of interest regarding this particular repair:

Weight of casting	5,600 lb.
Number of fractures	3
Dimensions of member at fracture points	6x8 in.
Weight of electrode used in welds	84 lb.
Man-hours in completing three welds	13 man-hours
Weight of charcoal used in heating	250 lb.
Current consumption	194 kw.
Average welding heat	250 amp.
Size of welding electrodes	¼ in.

After completion of welding it was necessary to drill several holes to fit the casting to its former uses. Two of these holes were drilled through the point of fusion. No difficulty whatever was experienced in drilling and tapping these holes. The weld had no hard spots at all. The entire top surface was chipped and filed to proper shape without any trouble.

Fig. 2 shows how the welds were extended out about ½ in., thus adding greater strength at the points subjected to the greatest stress.

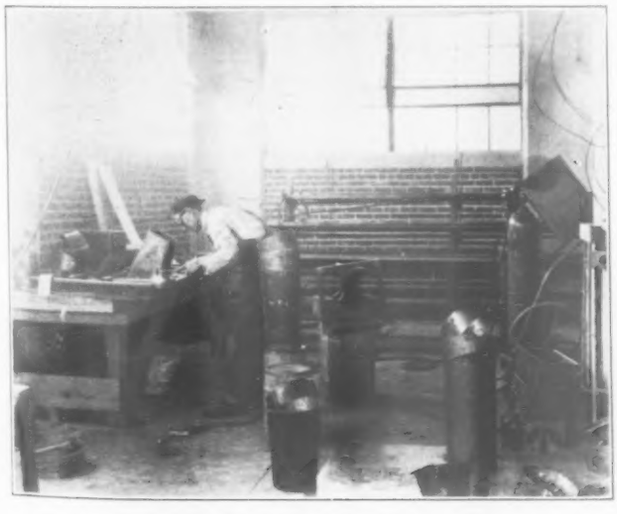
Due to the extremely fluid state of cast iron, it does not lay in beads when deposited across the arc but forms a small pool not unlike that formed by the oxy-acetylene welding flame. However, as a much higher degree of heat is obtained with the arc, the metal is much thinner, and remains in the fluid state much longer after the heat is taken away.

The weld must be built up as nearly level as possible to eliminate any possibility of the fluid metal flowing over and covering a "cold" portion of the weld. The welding operation should be carried on as rapidly as possible and should be allowed to cool slowly and evenly when completed. With the same precaution usually taken for the protection of the casting in gas welding practice, the average welder will not experience any great difficulty in the arc welding of cast iron by this process. He must, however, bear in mind the fact that he is working on cast iron and treat it as such.

WELDING IN NEW GRAIN MILL AND ELEVATOR

By J. C. Coyle

In the handling of grain from floor to floor of the new eight-story $750,000 mill and elevator of the Ralston Purina Company, at Denver, a great many chutes and pipes of black



Welding Pipes and Chutes in a Grain Elevator.

iron are used. In order to facilitate the flow of grain through these pipes, by having a smooth inner surface, all joints and flanges are gas welded. The temporary equipment, set up on the second floor of the mill for this purpose is shown here.

The main building of the plant is 110 by 180 ft., of reinforced concrete construction, with the exception of one side of the mill, which is partly brick. The head house is 56 by 75 ft. and 185 ft. high, towering well above the rest of the plant. In this are a large number of concrete grain compartments, from which the pipes mentioned lead to, and down through the floors of the mill. Near the head house are fifteen concrete storage tanks, each 18 ft. in diameter and 88 ft. high, in which grain is stored when unloaded from the railroad cars into hoppers beneath a concrete shed. In the mill there is a concrete stairway reaching each of the eight floors, with railing of 2 in. iron pipe, welded and secured to bolts inset in the concrete.

REPAIR JOB ON LARGE STEAM HAMMER

Under the work of forging a most rebellious piece of steel, the steam hammer at the Lowden Forge works, San Francisco, Calif., broke or cracked in three places. This is said to be the largest steam hammer in the vicinity of San Fran-

The Arrows Shown on This Huge Steam Hammer Point to Welds in the Piston Rod, Guide, and Base Block.

cisco, and its repair by welding saved the owner a considerable amount of both time and money.

The damage consisted of the piston rod snapped in two, a cracked guide, and, what was most serious, the breaking down of the huge cast-iron base block.

A representative of the Pacific Structural Welding Corp. happened into the forge plant while Mr. Lowden, the owner, was ruefully contemplating the loss of the use of his hammer for at least thirty days and the herculean task of taking the base block from its bed for removal to a foundry for rebuilding. Although skeptical at first, Mr. Lowden was assured that the base block could be repaired in place by electric arc welding, and that the entire job, including also the piston rod and the guide, could be completed in not more than ten days.

So arc welding was used, and the work was completed actually in eight days, the piston rod and guide being repaired at the plant of the welding company while the base was being built up in place. A total of 220 lb. of welding wire was used. Upon completion, after the anvil block was keyed in place, the hammer was subjected to a most severe test by forging

from an 8x8-in. billet of high-carbon steel the 100-ton hook shown in the illustration.

The weld in the base block had a depth of 7 in., and the steel-stud method of repair was used. The cast iron first was cleaned and then tapped at about 3 in. centers for the insertion of the studs, the purpose of which was to distribute the heat generated and also to absorb the stresses and strains developed. Cast-iron rod and mild-steel rod of quarter-inch size were used. The beads were laid parallel to the break, except every third bead, which was run at right angles to the two preceding. About 30 beads were necessary. Each bead was cleaned and hammered before applying the next one. Special precautions were taken on the piston rod and guide to preserve alignment, and the piston-rod repair was accomplished with high-carbon steel rod.

Acknowledgment is made to the Victor Welding Equipment Corporation, San Francisco, for their courtesy in furnishing the data and illustration of this interesting repair.

SHRINKING LOCOMOTIVE CRANK PINS WITH LIQUID AIR

No part of the railway locomotive, it is generally admitted, is subjected to more stress than the main crank pin on one of the drive wheels that grip the rails and force the train ahead. To keep them in place, the pins are made one ten-thousandths of an inch larger than the hole in the drive wheel. Ordinarily these pins are put into place by a force of 900,000 lb. in a gigantic press.

Yet a small can of liquid air poured around the pin has enough "cold power" to shrink it just long enough so it can be put into the hole by hand. The advantage of this method, according to locomotive men, is that a pin can be replaced without tearing the whole engine to pieces, thus saving the time of engines needed for service, as well as labor costs.

So far, liquid-air shrinking of crank pins as large as this is in the experimental stage, but J. Dickson, superintendent of motive power for the Spokane, Portland & Seattle railway system, is of the opinion that it holds possibilities, and that it will become a part of standard railway shop practice.

The application of a little can of liquid air on a job performed at the Vancouver, Wash., yards was the idea of Fred L. Huggins of the Portland Oxygen & Hydrogen Co.

DATE SET FOR INTERNATIONAL ACETYLENE ASSOCIATION CONVENTION

At a meeting of the Board of Directors of the International Acetylene Association, which was held on April 1st, it was decided to hold the Annual Fall Convention in Chicago on November 12th, 13th and 14th. The program committee has been appointed and it is expected that they will soon start making arrangements to secure speakers for the technical sessions.

WELDING RESEARCH AT PURDUE

"Welding and construction companies from all over the United States are sending problems which arise, to the Purdue University Engineering Experiment Station and the Chemistry Department at Purdue for solution," said Dr. H. L. Maxwell, a member of the engineering experiment station staff, recently. According to Prof. Maxwell, Purdue is doing pioneer work in welding research and is widely recognized as an authority on welding problems.

A stainless alloy steel which is resistant to acids and is used to a great extent in chemical plants resisted all efforts toward welding until the Purdue engineering experiment station took hold of the problem. Different methods were tried and after four months a satisfactory process was developed.

Experimental work in the use of illuminating gas with oxygen for welding is being carried on by H. H. Lurie. If successful, this new method will mean a great saving to industry.

Dr. Maxwell is frequently called to industrial plants to determine why high-pressure steel boiler welds have proved faulty. Many companies over the United States send for Purdue specialists or send samples to the university research laboratories for testing.

TRI-CITY WELDING SCHOOL

The Educational Committee of the Tri-City Plumbing and Heating Trade Development League, with headquarters at Rock Island, Ill., are sponsoring a school in welding. There are eight students in the class, consisting of journeymen plumbers and steamfitters from the various plumbing and heating contractors' firms of Rock Island and Moline, Ill., and Davenport, Iowa.

The school is conducted at the Manual Arts Building in Rock Island and classes are held two nights a week and will continue for a period of twelve weeks. J. J. Collins of Bettendorf, Iowa, is instructor.

The class was made possible through the cooperation of the Rock Island Board of Education, the State of Illinois Board for Vocational Education and the Air Reduction Sales Co. of Bettendorf, Iowa.

BOOK REVIEW

The Welding Encyclopedia, Seventh Edition, compiled and edited by L. B. Mackenzie and H. S. Card. 540 pages; 670 illustrations; flexible imitation leather binding. Published by The Welding Engineer Publishing Company, 608 S. Dearborn St., Chicago, Ill. Price, $5.00.

This book contains 200 pages of definitions and discussions of words and terms used in welding literature. This is followed by treatises on gas, arc, resistance, and thermit welding, which include instructions for welding all of the commercial metals by each of these processes. Separate chapters are devoted to such important applications of welding as pipe, tanks, boilers and structural steel. The subject of cutting and the subject of training operators are also given separate treatments. In the new addition extensive additions have been made to include up-to-date information on some of the newer applications of welding, such as aircraft welding, welding of machine parts, and structural-steel welding. Other important additions to the previous edition deal with the welding of special alloy steels and the welding of non-ferrous metals and their alloys.

THE SAMUEL WYLIE MILLER MEDAL

By action of the Board of Directors of the American Welding Society at its meeting on April 24, 1929, the Samuel Wylie Miller Medal, donated in 1927 by Mr. Miller for the period of his lifetime, has been established in perpetuity by the Society as a memorial to the donor.

The funds for the support of the medal will be supplied by the Society and will be in the custody of the Treasurer. The award will be made by a Board of Trustees consisting of three members appointed by the President, one each year for a term of three years (after the first two appointments for one and two years, respectively, have been served).

The Board of Trustees will make the award under the following rules and regulations:

1. Samuel Wylie Miller Medal shall be awarded annually for any meritorious achievement which, in the judgment of the Miller Medal Board of Trustees, has contributed conspicuously to the advancement of the art of fusion welding and cutting.

2. Individuals only, but of any country and of any age, shall be eligible for the award.

3. The award for any calendar year shall be announced and the medal, together with a suitable certificate, presented at an annual meeting following the year for which the award is made.

In accordance with the resolutions of the Board of Directors, the President has appointed the following Board of Trustees for the award of the Miller Memorial Medal: F. J. King, Linde Air Products Co., chairman (term 3 years, to April, 1932); C. A. McCune, American Chain Co. (term 2 years, to April, 1931); and F. M. Farmer, Electrical Testing Laboratories (term 1 year, to April, 1930).

WEST COAST ORGANIZATIONS COMBINE

On the 20th, 21st and 22nd of February there was held in Seattle, Wash., a Welders' Convention, at which time the consolidation of the organizations known as the National Order of Certified Welders and Associated Welders and Helpers took place. They now are included in one organization known as the Association of Certified Welders, the new group now covering the territory from Los Angeles, Calif., to Vancouver, B. C. Some of the purposes of this organization are to build up a measure of protection for the trade, assist wherever possible the advancement of the industry through cooperation with others who are interested in its development, and endeavor to maintain a high standard of skill and integrity among members. The convention consisted of two days' session of business with an educational program in the evening of the second day, at which talks were given by some of the most able men on the West Coast, together with demonstrations by some of the leading manufacturers of welding equipment. A caravan of cars on the 22nd, several blocks long, escorted by motorcycle police, visited the various points of interest throughout the city, among them being a visit to the gas-manufacturing plants, where demonstrations were given, which proved to be very interesting as well as instructive. On Saturday evening, as a "Grand Finale," a banquet was given in the Bergonian Hotel.

"It is our intention," states F. H. Cooper, secretary of the new organization, "to classify our workers for the various branches of welding and burning so that we may be in a position to furnish employers with the best skilled mechanics as required. We also intend to attempt the establishment of an apprentice system where young men engaged in steel working can in time be trained as expert welders. We believe this method of practical education is better than that of the technical school system."

NATIONAL WESTERN METAL CONGRESS

The second biennial National Western Metal Congress and Exposition will be held in the Civic Auditorium at San Francisco, the week of February 16, 1931, according to a recent announcement by W. H. Eisenman, secretary of the American Society for Steel Treating.

A general committee of four, headed by Ivan L. Johnson, superintendent of the Best Steel Casting Co., Oakland, Calif., has been formed to handle the local arrangements. The other members are Frank B. Drake, president of the Johnson Gear Co., Berkeley; Myron Bird, vice-president, California Saw Works, San Francisco, and R. S. Hirst, Hall-Scott Motor Car Co., Berkeley.

Western sections of twelve national societies will cooperate with the American Society for Steel Treating in arranging the technical programs and organizing the exhibition. Floor plans of the auditorium are now in preparation, and when completed will be mailed to exhibitors by Mr. Eisenman.

The first National Western Metal Congress and Exposition was held at the Shrine Auditorium, Los Angeles, in January, 1929. At that time a total of 176 companies exhibited. It is believed that the 1931 show will be even larger.

REMOVAL OF A. W. S. HEADQUARTERS

The increased growth of membership of the American Welding Society has necessitated the securing of larger headquarters. The Society's new location is the Engineering Societies Building, in New York City, the offices being on the same floor as Engineering Foundation, Inc., through whose courtesy the space was obtained.

COMING NATIONAL METAL EXPOSITION

Floor plans of the 12th annual National Metal Exposition, to be held at the Stevens Hotel, Chicago, September 22nd to 26th, have been mailed to prospective exhibitors, according to W. H. Eisenman, secretary of the American Society for Steel Treating and director of the exposition.

The facilities of the Stevens Hotel will provide a beautiful setting for the 1930 exposition, which is expected to surpass every previous show in convenience and attractiveness. For the first time all activities of the National Metal Congress and Exposition will take place under one roof. Technical sessions, the annual meeting of the Society, and other features of the Congress will all be held in the Stevens Hotel.

The 1930 show will cover approximately 75,000 sq. ft. of floor space. On the first floor of the hotel, in the great exhibition hall and foyer, will be set up the heavy displays. Second floor exhibits will be located in the grand ball room and its foyer and in the lounge, writing room, and main dining room of the hotel. No restrictions are imposed by the exposition management as to the showing of heavy machinery, whether or not in operation.

A unique feature of the exposition is its all-expense cost to exhibitors, a new departure in show management. The exhibitor's booth rental includes cost of cartage to and from the railroad terminals; erection and dismantling of exhibits; the installation of connections for gas, electricity, air and water, as well as the cost of the current, gas, etc., used; furniture, carpenter work, signs and other charges hitherto paid separately by the exhibitor. Rental costs per square foot vary with the requirements of the individual exhibitor.

Those interested in floor plans and rates may secure information from Mr. Eisenman, 7016 Euclid Ave., Cleveland, Ohio.

CALIBRATING PROVING RINGS FOR TESTING MACHINES

A new dead-weight testing machine of 100,000 lb. capacity was recently developed by the Bureau of Standards for determining the calibration constants of Whittemore-Petrenko proving rings and of similar devices. These proving rings are being used by laboratories as a means of calibration of testing machines. The newly developed testing machine is installed in the Bureau of Standards and is described in detail in Research Paper No. 147, of the Department of Commerce.

FLINTWELD HARD SURFACING ROD ANNOUNCED BY STEEL SALES

A recent announcement of the Steel Sales Corporation, Chicago, Ill., gives information regarding their new "Flintweld" rod which is made for hard facing and can be applied by either gas welding or arc welding. The rod is recommended for hard facing drilling tools, dredger teeth, airplane skid shoes, farm implements, dredger bucket teeth, tracks, truck wheels and frogs.

When applied with the oxy-acetylene torch, the surface of the base metal must be thoroughly cleaned; then the flame is adjusted with a slight excess of acetylene, and the base metal is heated to just below the melting point. The Flintweld metal is applied very much the same as bronze, taking care not to rework the molten metal and avoiding the necessity of putting one layer on top of another.

When applied by arc welding, it is also necessary to clean the base metal thoroughly. Reversed polarity is used, and with a $\frac{3}{16}$-inch rod the settings are 175 amperes and 20 to 22 volts. Care must be taken not to rework the molten metal and to avoid putting one layer on top of another.

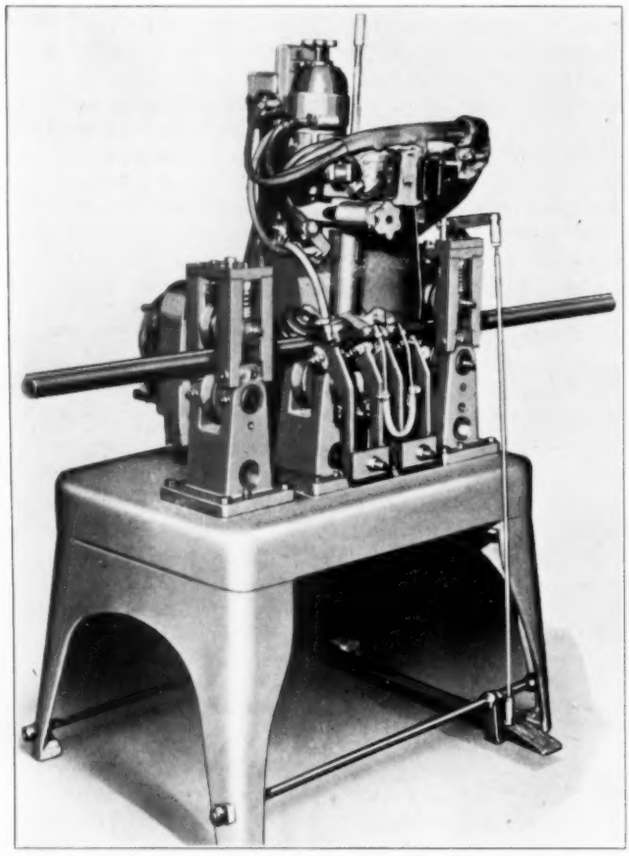
This new rod was recently used to build up the edges of a manganese steel gravel shoe used in a gravel mixer. The report received from this job was that the life of a new shoe was 4½ hours and the life of a shoe built up with Flintweld was 47½ hours in one case and 44½ hours in another case. It is stated that air cooled welds made either by gas or by the arc will show a Brinnel hardness of about 500.

AUTOMATIC ARC WELDING OF BRAKE CROSS SHAFTS

An automatic machine designed for the manufacture of brake cross shafts by means of the arc-welding process, is shown in the illustration. This machine welds a longitudinal seam along the

shafts as they come from the press on which they are formed. The shafts are fabricated of ⅛-in. plate and are formed into a tube 1¼ in. in diameter and 36 in. long. They come from the press with the two edges turned upward, perpendicular to the circumference and adjacent to each other. These edges are fused together on this machine as they progress automatically under the arc, at the rate of 36 in. per minute.

This welding machine embodies the features of the "electronic tornado," a development of The Lincoln Electric Co., Cleveland, Ohio, and utilizes the carbon-arc-welding process. The shafts are fed through the machine under the stationary electrode and progress automatically at a predetermined speed as the seams are welded. No filler rod is needed on this particular job.

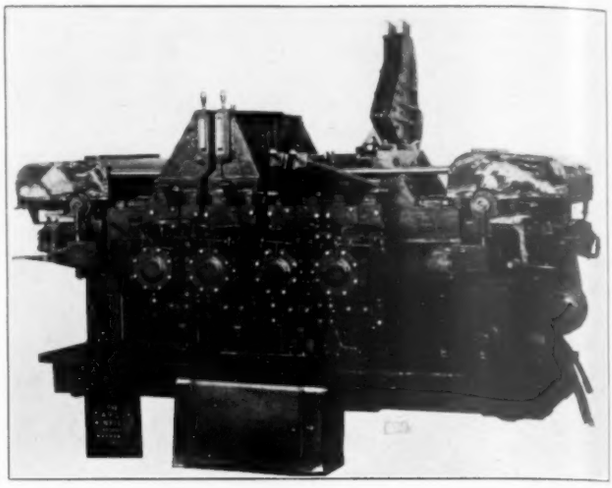


As the Brake Cross Shaft Passes Through This Machine, the Seam Is Automatically Welded.

FLASH WELDER FOR AUTOMOBILE TRUNKS

The application of welding to automobile manufacture has been extended to the making of trunks by use of the machine shown in the illustration. A completely welded trunk is shown at the base of the machine. This trunk consists of two stampings or sheet-metal ends which are flash welded by the electrical resistance method to the central piece, both ends at once, at the rate of 60 to 100 trunks per hour.

The machine itself consists of two separate welding machines mounted on a common base and acting in unison. Air clamping by toggle action is employed, and each machine is motor driven through silent chain and suitable gears. The upsetting is accomplished by two identical cams actuating the two rollers mounted on the slide at one time. After the pieces have been welded into one unit and the unclamping is accomplished, the slides are returned to the starting position by air-cylinder action. The entire machine weighs approximately 11 tons. Two 250-kva. continuous-duty welding transformers are used. The dies are of aluminum-bronze properly machined and fitted, and the terminal castings are water-cooled throughout. This machine is a product of The Taylor-Winfield Corp., Warren, Ohio.



This Flash Welder Fabricates the Automobile Trunk Shown.

WELDING TUBING AT FASTER SPEEDS

An acyclic generator, driven by two 35-hp. motors, has been developed by the American Electric Fusion Corp., 2610 Diversey Ave., Chicago, Ill., for use on tube-forming machines. When the usual 60-cycle frequency is used for welding, the company states, high speeds result in a weld in the form of a stitch—that is, the seam has a welded spot, followed by an unwelded portion, brought about by the current fluctuations of 7,200 per minute. At a speed of 60 ft. of weld per minute, for example, the stitches or recurrent variations in welding appear along the tube approximately every one-tenth of an inch.

(Left) New Acyclic generator installed on Tube-Forming Machine. (Below) Close-Up View of Generator.

It is to overcome this condition that the acyclic generator was developed, according to the company. This generator delivers current up to as high as 20,000 amp. at 2½ volts. Circular bus bars, to which the welding rings are attached, surround the stator of the generator. While the generator rotor is running at a high speed, the frame itself rotates slowly over the seam of the tube as it passes beneath the generator.

On preliminary trials, it is claimed, welding speeds as high

as 200 ft. per minute were readily obtained with this unit, and it is anticipated that with increased excitation and horsepower these speeds can be doubled.

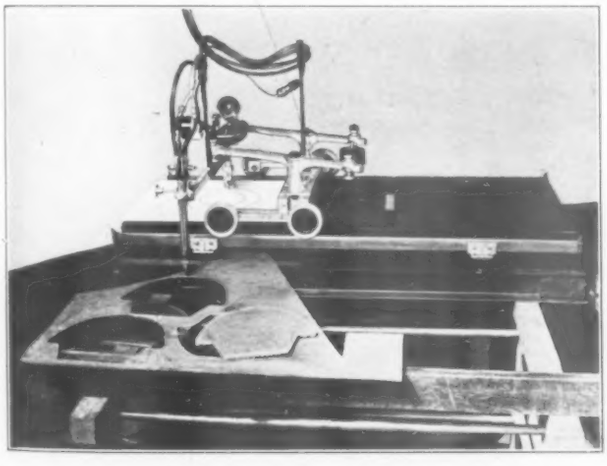
The nature of the current being direct current—that is, non-fluctuating—the welding temperature is likewise non-fluctuating, producing a smooth, continuous weld of parent-metal strength.

NEW CAST-IRON ELECTRODE

A new welding electrode for arc welding of cast iron is being produced and distributed by American Arc Welders, Duluth, Minn., under the trade name "Arcast." These new electrodes are described as being composed of close-grained gray cast iron and covered with a specially prepared flux. They are intended for use in the repair of iron castings in foundries, factories, shipyards, railroads, machine shops, etc. The manufacturers state that these electrodes make possible a thorough penetration with easy control and close localizing of the heat. Particular mention is made of the free flowing quality of the metal. It is said that since this new electrode has the same co-efficient of expansion as other iron castings, it prevents the formation of checks, cracks, and pin holes which occur when steel electrodes are used, at the same time producing a weld which is easily machined. They are already in use in a number of welding shops, and a recent demonstration at a large steel plant produced very favorable results.

GAS CUTTING MACHINE OF WIDE RANGE

The illustration is that of a shape-cutting machine having a cutting range sufficient for a good many purposes and reasonably priced so as to be within the reach of practically every machine and welding shop considering entering the field of fabrication. This machine, which is manufactured by the General Welding & Equipment Co., 66 Brookline Ave., Boston, Mass., has a cutting width



New Gas Cutting Machine of Simple Design.

of 2 ft. and a cutting length of 4 ft., which is said to be ample for practically 75 per cent of all purposes. By lengthening the table and the rails the cutting length can be conveniently extended. The machine can carry more than one torch. A large machine of this type with the exceptional rectangular cutting range of 10 ft. wide and 21 ft. long was recently put into operation.

"WACHS" ELECTRODE HOLDER

A light-weight and well-balanced metallic-electrode holder with a round handle that fits the hand and ventilated so the holder can be used continuously without becoming uncomfortably warm, has been announced by the Northwestern Manufacturing Co., Milwaukee, Wis.

This device, known as the "Wachs" metallic-electrode holder, is also characterized by the total absence of springs for compressing the jaws onto the electrode. Instead, a simple, trouble-free compression lever is employed, having a protective rubber coating and capable of being locked in place by a roller operating against a fixed ratchet. The roller and ratchet are made from wear-resisting, hardened tool steel. The gripping surface of the copper jaws is free from corrugations, so the jaws make the maximum contact surface with the electrode, thus minimizing the resistance drop between the jaw and the electrode. The jaws are welded in place, and the rod can be held at any desired angle. The elec-

This Holder Grips the Electrode Firmly Without the Use of Springs.

trode is gripped by pressing down on the lever with the thumb, and is released by a slight upward pressure on the lever. The cable is held in place by a wedge.

This electrode holder may be had in two sizes: No. 1 for electrode sizes from ⅛ to ¼ in. and currents up to 400 amp., and No. 2 for electrode sizes from ¼ to ½ in. and currents between 400 and 800 amp.

BOOKLET DESCRIBES MANY INDUSTRIAL APPLICATIONS OF ARC WELDING

The economical production of structural designs by arc welding is described in bulletin GEA-995A, a General Electric publication that has just come off the press. The application of this process to the fabrication of machine frames, bases, and other designs, resulting in a saving over the cost of castings, and to large outdoor structures and tanks and pressure vessels, is illustrated. Consideration is also given to the arc welding of pipe lines, steam and water mains, power and heating equipment, and jigs, fixtures, and dies. Machines for the welding of "battledeck" floors, automobile parts, and railroad equipment, are shown in service. Other sections of the booklet relate to cast-iron welding by the electric arc process, barge building, and atomic-hydrogen welding. Information is given on the General Electric arc-welding school and on the company's welding equipment.

An automatic welding head of the magnetic-clutch type, together with the control panel, is also described in a new General Electric bulletin, GEA-556C.

SMALL-SIZE SPOT WELDING MACHINES

A folder describing "Eisler" electric spot welding machines is being distributed to the trade by the Eisler Engineering Co., Inc., 740-772 S. Thirteenth St., Newark, N. J. These welders handle wire or sheet stock as fine as 0.0005 to ⅛ in. Information is given on adjustments, transformer capacities, voltage steps, design, and operation. Various types of these machines are illustrated, as well as different types and capacities of transformers. Some of the details of construction also are shown.

HARD FACING IN THE OIL FIELDS

The preparation of oil-well bits and other tools for withstanding the rigorous service of drilling for oil, is elaborated on in a 31-page bulletin bound in loose-leaf style and issued by the Haynes Stellite Co., Kokomo, Ind. Of particular interest are the procedure controls given for hard facing with Haynes Stellite and hard setting with Haystellite. The distinct steps of these processes are described fully and illustrated so the man in the field should have no trouble in following the procedure and obtaining the high grade workmanship that will insure a long-life tool. Twenty-eight different oil-well tools on which Haynes Stellite products are adaptable are shown, as well as several simple fixtures used for

applying these products to drilling tools. The general properties and grades of Haynes Stellite are described.

BOOKLET ON ARMCO INGOT IRON PLATES

"Pure Iron Plates for Long Service" is the title of a 20-page booklet describing the characteristics of Armco Ingot Iron and comparing this iron with steel in the matter of serviceability. Particular emphasis is laid on the "purity" of this iron, which results in a high degree of resistance against the corrosive action of the natural elements and of gases at high temperatures. Uniformity of the product is also stressed, and interesting information is given concerning the welding excellence of Armco Ingot Iron and its unusual ductility, making for a high degree of workability. The physical and tensile properties of this iron are listed, and cases are shown and described as examples of some of its varied uses. The advantages of Armco Ingot Iron as material for welding rods and electrodes are also discussed. This booklet is issued by The American Rolling Mill Co., Middletown, Ohio.

WELDING OF CAST IRON

The properties of cast iron, and the welding of cast iron and its preparation for welding are discussed in a 51-page booklet published by the Suffolk Iron Foundry (1920) Ltd., Stowmarket, England. The aim of this booklet is to acquaint the reader with the use of "Ferro-Silicon," "Super-Silicon" and "Sifbronze" welding rods as well as their respective properties and spheres of application. A number of interesting examples of welding are shown. The present edition of this booklet is the fifth.

STEEL "FACT BOOK"

Bascule, bent-eye, bulldozer, cantilever, club dolly, extrados, gantry, gib, goose-neck, gusset, hicky, jig, jumper, locus, lute, outhaul, picking, pinny, puddle, purlin, rabbling, scribe, snips, spandrel, strut, toggle are among the more than 20,000 terms familiar to the steel constructor which are defined in the second edition of the "Fact Book" now being issued by the American Institute of Steel Construction. The first edition of this volume was issued just a year ago. The revised edition includes many of the important facts regarding steel construction never before assembled for ready reference.

A directory of the steel constructors of North America, the statistical growth of the industry, bibliography, motion pictures, stereopticon slides, and innumerable other handy facts have been included.

NEW N. F. P. A. REGULATIONS ON ACETYLENE EQUIPMENT

The National Board of Fire Underwriters has just issued a new edition of the N. F. P. A. regulations for the installation and operation of acetylene equipment for lighting, heating and cooking. This standard was prepared by the N. F. P. A. Committee on Gases and was adopted by the association at its last annual meeting. Formerly the rules for such installations were included in those of installations of acetylene equipment generally, including welding. The new rules relating to the storage of calcium carbide are more liberal than in the past and coincide with the regulations for the storage of carbide used for welding and cutting purposes. Copies of the new rules may be obtained from the offices of the association, 30 East 42nd St., New York City, or directly from the National Board of Fire Underwriters, 85 John St., New York City.

A. F. JENKINS ISSUES BOOK OF POEMS

Alexander F. Jenkins, who as president of the Alexander Milburn Co., is widely known in the welding field, has been accorded a place among present-day American poets by the publication of a collection of 81 of his poems by The Stratford Company, of Boston, Mass., under the title, "My Argosy and Other Poems." The poems show a well-developed technique and are emotional in substance. The locations in which many of the poems were composed are revealed in foot notes. Many of these were in the Old World or on board ship.

TO PROMOTE SALE OF BURKE EQUIPMENT

To more thoroughly establish the name "Burke" in the minds of the buyers of electrical equipment, the Burke Electric Co., of Erie, Pa., has adopted a program of advertising in business papers, coupled with aggressive sales efforts. This company was founded in 1904 by James Burke, who was an Edison pioneer and a well-known figure in the electrical industry. The "Burke" arc welder, which was one of the first such machines to be put into the field, will be among the products to be featured in these advertisements.

DON'T OMIT STREET ADDRESSES

Advertisers will benefit from the use of a complete street and number address in their advertisements, as it will aid the prompt dispatch of their mail, says Arthur C. Lueder, postmaster, Chicago, Ill. On nearly 50 per cent of the advertisements intended to evoke a reply, which appear in newspapers and magazines, the street and number address is omitted in the advertiser's signature. Thus, all inquiries sent in are without a street and number address, which, Mr. Lueder points out, not only imposes a constantly increasing burden upon the postoffice, but seriously interferes with the prompt dispatch of such mail. In fact, non-delivery is often the result of the failure to furnish a complete street address.

SHAWINIGAN COMPANY'S ANNUAL REPORT

A copy of the Annual Report of the Shawinigan Water & Power Co. for 1929, recently published, indicates that the associated companies have been operating at capacity during the preceding year and that there is a considerable amount of new construction in progress. The report is beautifully illustrated with views of the company's property, including the carbide plant and the plant of Shawinigan Chemicals, Ltd., at Shawinigan Falls, and colored maps showing the location of plants and the distribution of power and products of the corporation.

DEATH OF JOHN KREUSI

John Kreusi, president of the American Lava Corp., of Chattanooga, Tenn., died of pneumonia in that city, on March 25th, at the age of 38. He was the son of the late John Kreusi of Schenectady, N. Y., who was associated with Thomas A. Edison in the early days of electricity. Mr. Kreusi was educated at Union College and Cornell Unversity and during the World War he was a captain in the A. E. F. He has long been a member of the International Acetylene Association and at the time of his death was Chairman of the House Lighting Committee.

ESTABLISHES NEW MAINTENANCE DEPARTMENT

Announcement has been received that the Burdett Oxygen Co. of Oklahoma, a subsidiary company of Compressed Industrial Gases, Chicago, have opened up a very elaborate Maintenance and Repair Department for the purpose of overhauling, repairing and conditioning all types of welding equipment and acetylene generators. Various types of machinery and tools have been installed at the store of the Burdett Oxygen Co., which is located at 510 N. Hudson St., Oklahoma City. Skilled mechanics, familiar with equipment construction, and trained at welding equipment factories, will be in charge of this new maintenance bureau, and a large stock of repair parts will be maintained so that equipment can be readily overhauled and reconditioned at minimum expense within a reasonable time.

OXYGEN PLANT COMES TO AID OF RACER

When Kaye Don, the British auto racer, recently made preparations for a speed test to establish a new world's record at Daytona Beach, Fla., he could not obtain sufficient pressure to fill the tires on his 24-cylinder Sunbeam racer, so he relied on the Burdett Oxygen Co. of Atlanta to supply him with air at high pressure. R. G. Wilson, district manager of the company, announced that his firm sent Don eight tanks of compressed air of 1,800 lb. pressure, and a few days later the Englishman telephoned the Burdette company for four more tanks in order to obtain the 1,000 lb. necessary to hold up his heavy machine.

FRENCH WELDING ENGINEERS VISITING THE UNITED STATES

M. Lebrun, Director of La Soudure Autogene Francaise, Paris, and J. Brillié of the engineering staff of the same company, which is one of the largest and best known French companies in the welding appliance field, arrived in New York on April 9th for an extended visit to the industrial centers of the United States. Mr. Brillié has a considerable acquaintance among some of the leading welding establishments of the country on account of the contacts made on a previous visit. These gentlemen are among the foremost welding enthusiasts of their native country, and the purpose of their visit is, of course, to get better acquainted with the progress which is being made in this country in the applications of welding and in the devolpment of safe and economical procedures.

NEWS OF THE INDUSTRY

The Lincoln Electric Co., of Cleveland, Ohio, has opened new branch offices in Saginaw, Mich., Fort Wayne, Ind., and Oil City, Pa. The Saginaw office is at 338 Barnard St. and is in charge of J. E. Luter. The Fort Wayne office is in charge of D. H. Carver and is located at 225 E. Columbia St.; and E. D. Anderson has been placed in charge of the new office in Oil City.

A. H. Peir, of the A. H. Peir Co., Los Angeles, Calif., distributors of Lincoln Stable-Arc Welders, has just returned from Honolulu, H. T., after having spent several months pleasure touring in several countries abroad.

Three train-loads of steel pipe to be used as water mains in the city of Spokane have been shipped from the Steel Tank & Pipe Co's. plant in Portland, Ore. This large order of 36-in. pipe required 110 flat cars to transport, and is the second major order within two years that Spokane has placed with the Portland plant. In the same set of cars the Steel Tank & Pipe Co. shipped a large storage tank made in their plant for the Butte, Mont., distributing center of the Shell Oil Co.

How one distributor of welding supplies is doing his small bit towards relieving the general unemployment conditions is indicated in a notice sent out by Martin's Service Co., 5528 Baum Blvd., Pittsburgh, Pa., to all their customers, announcing their adoption of the five-working-day week. "Under the new policy and with the natural, steady growth of our business, we can add three men to our shop force and two girls to our office force," states the announcement. "Our shop equipment is such that we can turn out repair work rapidly and accurately; and with an increased shop and office personnel, we can produce as much in five days as we do in our present five and one-half day week." The notice is a masterly sales talk of the company's "policy of fairness and justice" to their customers, to those from whom they buy, and to those who work with them.

The Oregon Welding & Machine Works, 75 N. Park St., Portland, Ore., are preparing for the return of business confidence by installing a battery of new machines to take care of their increasing business. Manager "Shorty" Minor takes great pride in the work turned out recently with their new cylinder-boring machine and a power machine for the reboring of main bearings. Their body works department is very busy just now turning out the large bodies for the interstate and local bus freight lines.

Wm. J. Chesak has joined the organization of the Modern Engineering Co., 129 N. Campbell St., El Paso, Tex. Mr. Chesak has a large acquaintanceship among the welders of the southwest. In 1919 he organized the Acetylene Products Co. in El Paso and built it up to a large organization with plants and warehouses in El Paso and Phoenix, Ariz. On account of ill health he sold this business in the early part of 1929. The Modern Engineering Co. is managed by W. H. Miller and handles an extensive line of welding equipment and supplies.

Tube-Turns, Inc., of Louisville, Ky., announces the appointment of the following distributors: The E. F. Keating Co., 452 Water St., New York City; Himelblau-Agazim & Co., 30 N. Dearborn St., Chicago, Ill.; and Stewart Machinery Co., Buder Bldg., St. Louis, Mo. W. P. Curley and A. L. Breyvogel will continue as managers of the New York and Chicago offices, respectively.

E. C. Caluwaert, formerly with the Smith Welding Equipment Corp., is now associated with the Northwestern Manufacturing Co., of Milwaukee, Wis.

The Electric Welding Machine Co., of Wheeling, W. Va., has obtained the Wheeling plant of the Wheeling Machine Products Co., together with the welding and machine-repair departments, and will consolidate the businesses. A program of expansion is planned.

The Wichita Falls Oxygen Co., 110 Indiana Ave., Wichita Falls, Tex., has issued a folder of data on welding gases. Included are tables on gas pressure and consumption and tip sizes for different thicknesses of metal, melting temperatures of various metals, conversion table of Centigrade and Fahrenheit temperatures, weights of commercial gases, and average yields of acetylene from different grades of carbide.

The Harris Calorific Co., of Cleveland, Ohio, has appointed the Virginia Welding Co., of Charleston, W. Va., as sales agents. F. S. Rice, who is proprietor of the Virginia Welding Co., has been engaged in the welding supply business for fourteen years.

The Barnsdall Corp., of Okmulgee, Okla., is planning the construction of a welded steel pipe line running from that city to Milwaukee, Wis., and passing through Kansas City, Mo., and Des Moines, Iowa. The line, which will be about 800 miles long, is estimated to cost about $10,000,000, including booster stations, etc. The project will be carried out by the Barnsdall Transportation Co., a subsidiary.

Dr. A. Krebs, Treasurer of the General Welding & Equipment Company, Boston, Mass., writes that he is planning a trip to Europe in the near future and intends to remain there long enough to visit the International Acetylene Convention in Zurich, Switzerland, the beginning of July. These Conventions are held every three years and are particularly interesting because they draw together men from many different countries who are interested in the uses of acetylene.

The Los Angeles, Calif., chapter of the American Welding Society held their annual meeting on the evening of March 28th at the Engineers' Club, 833 S. Spring St., with an un-

usually large number in attendance. Mark Levy, of the Pacific Copper & Brass Co., gave an interesting talk on "Permanent Welds," which was followed by a treatise by C. J. Nyquist, of the A. H. Peir Co., a charter member of the Society, on "The American Welding Society and Welding, Yesterday and Today." Talks were also made by "Bill" Millinger on "Our Future as Members," by "Andy" Lucas on "Welding—and How!", and by others.

O. H. Eschholz, manager, and W. D. O'Connor, member, of the Patent Department, Westinghouse Electric & Manufacturing Co., were recently admitted to the bar of Allegheny County, to the bar of the Supreme Court of Pennsylvania, and to the bar of the District Court of the United States, Western District of Pennsylvania. Mr. Eschholz is widely known in the welding industry for his investigations and literary contributions in that field.

The teaching of Chinese students to weld is the novel, if not unique, experience of S. W. Dunn, of the Adcox Schools, of Portland, Ore. Eleven of these Orientals are taking the ground course in aviation, which includes some work in welding, and four more are coming from China for this course. Twenty-five Chinese who are already in the United States will be taking this course this summer, says Mr. Dunn. After completing the course, these students intend to return to their native country.

About 240 men in the Chicago district who are interested in steel treating and die making recently heard a lecture on the Carb-O-Flux arc welding process given by R. W. Holt, research engineer of the Fusion Welding Corp., of Chicago, and took part in the discussion that followed. The occasion was the regular meeting of the Chicago Chapter of the American Society for Steel Treating, held on the evening of April 10th at the City Club, Chicago. Slides were used to illustrate the lecture and many samples of materials welded by this method were on display. The meeting was opened with a talk by J. B. Green, president of the Fusion Welding Corp., on the possibilities of infra-red-ray photography, in the course of which slides were shown of the electric welding arc and gas welding flame, the original pictures of which were taken by this method. A dinner preceded the meeting.

The Sutton-Garten Co., welding engineers and contractors of Indianapolis, Ind., have erected a new, modern welding plant at 401-415 W. Vermont St. which they term a "super job welding shop." This company does gas, electric arc, spot, and butt welding, and is equipped for emergency field work.

"Safe Welds" and the scientific prediction of weld behavior, was the subject of a lecture by Robt. E. Kinkead, consulting engineer, before the meeting of the Cleveland, Ohio, Section of the American Welding Society, held at the rooms of the Cleveland Engineering Society, in Carnegie Hall, on the evening of April 4th.

The Compressed Gas Manufacturers' Association have moved their offices to Room 1901, 110 West 40th St., New York City. A conference room is maintained at the new location for the accommodation of committees or other group meetings, and all members visiting in New York City are urged to make the new office their headquarters.

The Air Reduction Sales Co. had an exhibit at the Oil Equipment and Engineering Exposition, held in Los Angeles, Calif., March 16th to 23rd, at which they demonstrated Oxygraph and Radiagraph manchines, for automatic torch cutting, and exhibited welding and cutting equipment, a 300-lb. acetylene generator, a 20-cylinder oxygen manifold, cylinders of oxygen and acetylene, and drums of carbide.

The Alco Oil Tool Co., of Los Angeles, Calif., is delivering a rush order of hard-faced drilling bits and other equipment by truck from their plant in Los Angeles to Oklahoma City, Okla., a distance of approximately 1,800 miles. The trip is being made with a rebuilt Ford truck equipped with auxiliary gears. The load includes 67 O-Type digging bits, together with other products of the company, making a total weight of about 4,000 lb. The trip will be made in three days. The Alco company has a branch warehouse in Oklahoma City, which field is the most active at this time of all the Mid-Continent oil fields.

The Compressed Gas Manufacturers' Association has forwarded its annual report to its members. This report contains the papers read at the annual meeting, together with discussions, also reports of committees and officers.

The Atlanta, Ga., branch of the Commercial Acetylene Supply Co., Inc., has been moved from its former location at 708 Thrower Bldg. to 680 Hamilton Ave. S. E.

A letter received from Mr. C. Raggett, Secretary of the Institution of Welding Engineers, London, reports that since the first of the year, the membership of that organization has been increasing, and at present time the total is well over 200.

Because his business calls him out of town so much of the time, Mr. E. W. P. Smith, Consulting Welding Engineer, and Chairman of Cleveland Section of American Welding Society, finds it necessary to resign as Chairman.

Announcement has been received of the consolidation of the Ohio Valley Oxygen Company, Cincinnati, Ohio, with the Air Reduction Sales Company, New York.

D. L. Driscoll, of Long Beach, Calif., has recently been placed in charge of the management of the Superior Oil Well Equipment Co., located in the Signal Hill oil field of southern California. The plant was formerly under the management of E. S. Dimmick. The shop equipment is being completely overhauled and repaired, new lathes and other equipment is to be installed, and an up-to-date shop is planned to be in operation by May 1st. Specializing in oil well fishing tools is to be one feature of the new plant, together with general oil-tool work, blacksmithing, and both gas and electric welding. Mr. Driscoll is thoroughly experienced in this work, and is widely known throughout southern California, having been engaged in this work for over 22 years in this section of the state.

Classified Ads

Help Wanted—75c per line, minimum 4 line
Jobs Wanted—4 lines free.
Other Ads—$1.00 per line, minimum 4 lines.
Counted 8 words to line. Add 6 words for keyed address.

Working Shop Foreman Wanted for job welding shop located in New York employing ten men. Must be thoroughly experienced; all-around man especially on automotive welding and finishing; used to handling men. Either a machinist or welder by trade who can obtain maximum output at low cost and without comebacks. Moderate salary and bonus to start. Don't apply unless you have successfully handled a shop of this size or larger. Write full details in first letter in strictest confidence. Address Box 246, The Welding Engineer.

Foreman Wanted—Welder thoroughly trained in oxy-acetylene and electric welding to take charge of new welding job shop. Must understand practical theory of welding and be able to read blueprints and estimate jobs. Good personality, mechanical and business ability are essential. Location: Boston, Mass. Address Box 247, The Welding Engineer.